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August 2018
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All About Agitators

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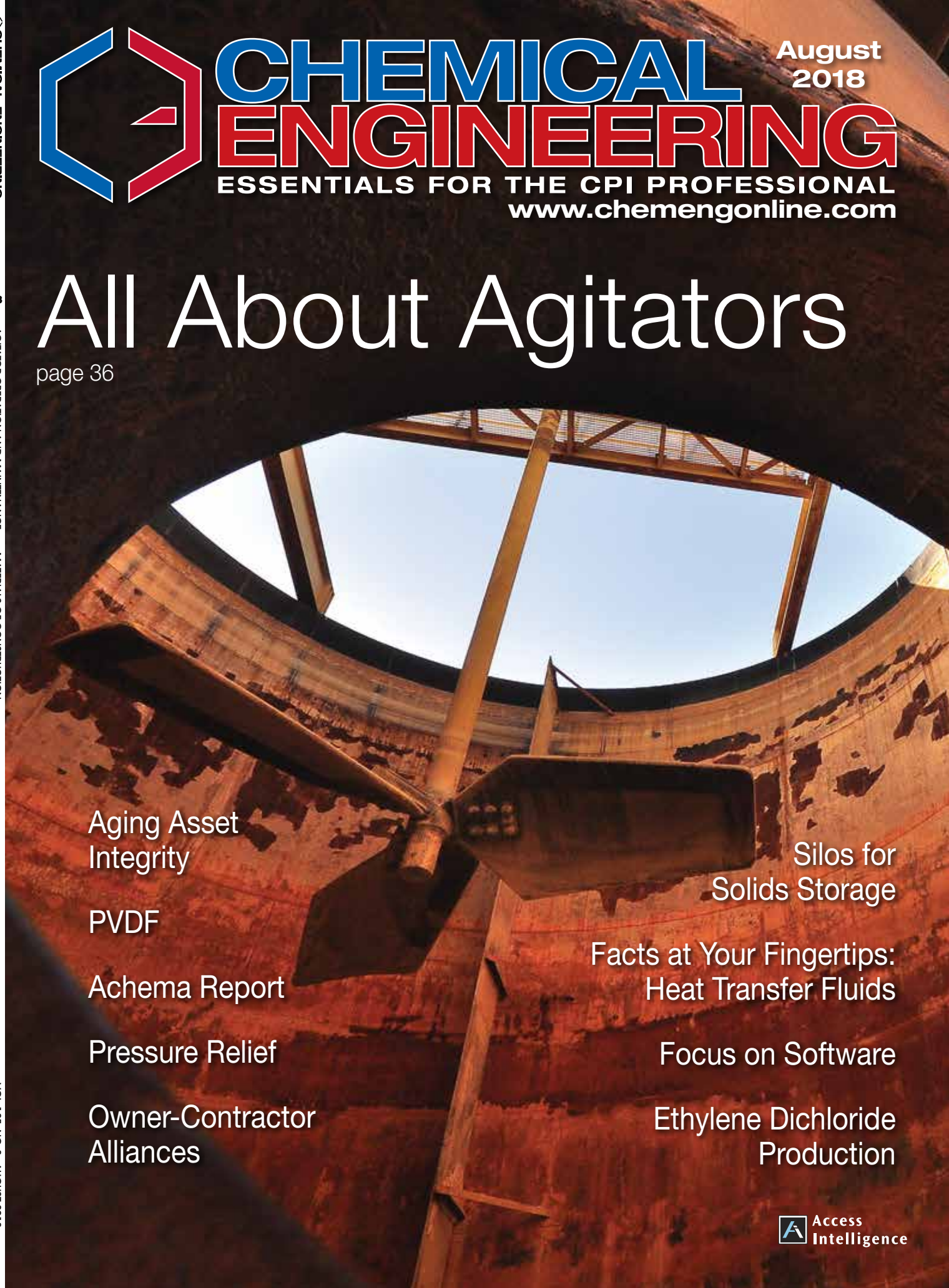

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PVDF

Achema Report

Pressure Relief

Owner-Contractor Alliances

Silos for Solids Storage

Facts at Your Fingertips: Heat Transfer Fluids

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Editor's Page

Impressions of Achema

I first visited Achema some years ago, while I was working in Europe as an R&D project leader for a large, international chemical company. It was my first year living in the Netherlands on an expatriate assignment from the U.S., and I, along with several of my engineering colleagues, set off on a roadtrip from the Netherlands to Frankfurt, Germany. All of my European colleagues seemed to be very familiar with Achema, but for me, it was my first exposure to this important event for the chemical process industries (CPI). I recall my first impressions of Achema — it was huge, larger than any trade fair I had previously attended. Even though I spent several days there, I remember thinking that there was so much more to see and learn.

Achema

Achema (www.achema.de) is one of the largest exhibitions and conferences for the CPI in the world. It occurs once every three years at the fairgrounds (Messe) in Frankfurt am Main, Germany, and is organized by Dechema (www.dechema.de), a non-profit professional association for chemical engineering and biotechnology. The event was started in 1920, and will reach its centennial anniversary by the next exhibition in 2021.

In recent years, I have had the privilege of attending Achema regularly to cover the event for *Chemical Engineering* and the *Achema Daily*. The editors of *Chemical Engineering* magazine, together with colleagues from Vogel, a German publishing company, write and produce the *Achema Daily*, which is distributed in print on the fairgrounds and digitally worldwide.* The publication is written in both English and German. Even with a total of 256 pages over the five days of the event, the *Achema Daily* could cover only part of what was going on at the trade fair.

The *CE* editors at Achema (left to right): Scott Jenkins, Mary Page Bailey, Dorothy Lozowski, Charles Butcher and Gerald Ondrey

This year's event was held June 11–15 with more than 3,700 exhibitors from 55 countries and about 145,000 visitors. Three focal points for the event included: flexible production, focusing on modular solutions; biotech for chemistry, which showcased the integration of biotechnological methods into the CPI; and chemical and pharma logistics, which showed how the supply chain is being integrated more and more into the process industries. There was much activity around digitalization and new trends in automation.

After all these years, Achema does not disappoint — it is still huge, and offers something for everyone in the CPI.

In this issue

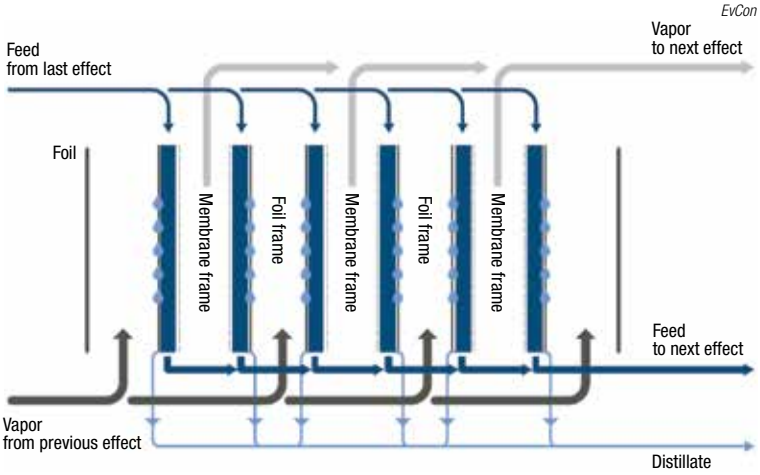
For those who were not able to attend Achema, we have summarized some of the highlights in this month's news story on pp. 14–17, as well as in a brief article on new membrane distillation technology in our Chementator section. And, many of our new products this month were featured at the event as well. We hope you enjoy reading these, along with our wide variety of articles on agitators, materials of construction, solids processing and much more. ■

Dorothy Lozowski, Editorial Director

*As an example, this link is to one of the five *Achema Daily* issues: https://epaper.vogel.de/process_87418/index.html

Vacuum-aided membrane distillation results in ultra-pure water

Edited by:
Gerald Ondrey



At Achema 2018 (June 11–15; Frankfurt am Main, Germany), EvCon GmbH (Pliening-Landsham, Germany; www.evcon-water.com) showcased its new UPWater treatment system, which employs a patented vacuum multi-effect membrane distillation (VMEMD) technology to obtain ultra-pure water using less energy than comparable water-treatment processes. VMEMD uses a hydrophobic membrane constructed of corrosion-resistant plastics with 0.1- to 0.5-µm pores fine-tuned to be permeable only to high-purity steam. The membrane selectively rejects any impurities in the feedwater stream along with the water itself. At vacuum conditions, water and pure steam are passed through different membrane stages, or effects (diagram). The steam and water progressively condense and evaporate as they pass through the system, and as more water impurities are trapped by the membranes, a stream of pure water is created. Steam flows through the system efficiently due to the pressure and temperature differentials between the membrane effects, which also help to induce controlled condensation.

"The heating steam condenses, transferring its heat to the feed, which is evaporated. Steam is collected within the effect and is used for heating in the next step," says Norbert Borgmann, development and project manager for EvCon. Lower operating temperatures further contribute to UpWater's thermal efficiency. "The multi-effect distillation process is run in a vacuum so that evaporation can occur at temperatures under 100°C," explains Borgmann.

EvCon has run prototype systems for pharmaceutical manufacturers and also demonstrated the system's robustness in handling sugar-containing solutions. The first company to utilize this technology commercially is Rochem Separation Systems India Ltd. (Mumbai; www.rochemindia.com). According to Prerak Goel, director of Rochem Separation Systems, the company operates five UpWater units across India, including installations treating wastewater from a steel mill and a pharmaceutical production site. "One benefit is the possibility to have a metal-free concentration unit that can handle different kinds of chemistries with no corrosion issues," says Goel. He mentions that Rochem plans to add several additional UpWater units later this year.

TPA FROM PET BOTTLES

A chemical method previously developed for recovering monomers from polyester blend fabrics and textiles has now been adapted for use with waste plastic bottles made from polyethylene terephthalate (PET). The BCD Group (Cincinnati, Ohio; www.bcdinternational.com) developed a modified base-catalyzed decomposition (BCD) process that takes place in stirred-tank reactors using a base and a proprietary phase-transfer catalyst to separate cotton-polyester blend fabric components and depolymerize polyesters (*Chem. Eng.*, November 2016, p. 9). The company has tested the process at laboratory and pilot scales. Now, the modified BCD process has been optimized for the recovery of terephthalic acid (TPA) from waste PET bottles. The advantage of this process over alternatives is that it is carried out rapidly at low temperatures and with inexpensive reagents, the company says. The TPA can be used as raw material for other polymer products.

RENEWABLE NH_3

Thyssenkrupp Industrial Solutions (see also story on p. 6) has recently been awarded a

(Continues on p. 6)

Australian minerals shipped to South Korea

Battery metals producer Australian Mines (Perth, Western Australia; www.australianmines.com.au) is scheduled to export the largest sample of battery-grade cobalt and nickel sulfate ever recorded from Australian mined and processed ore. The company will send 40 kg of nickel sulfate and 4 kg of cobalt sulfate samples from its Sconi cobalt-nickel-scandium project in northern Queensland to SK Innovation (Seoul, South Korea; www.skinnovation.com).

SK Innovation will use the samples in its electric-vehicle manufacturing plants. SK Innovation will assist Australian Mines in optimizing the Sconi bankable feasibility study and help with enhancing the proposed processing plant and mining operation through sample validation.

The shipment ore was transported from Queensland to Australian Mines' demonstration plant in Western Australia for trial processing via high-pressure acid leach and solvent extraction. The plant produces samples containing more than 98%-purity cobalt sulfate and 99%-purity nickel sulfate, without using a third-party commercial laboratory and exceeding SK Innovation's specifications for electric vehicle feed materials.

Under the terms of an agreement with SK Innovation, Australian Mines will supply up to 12,000 metric tons (m.t.) of cobalt sulfite and up to 60,000 m.t. of nickel sulfate per year from the Sconi project for an initial period of seven years, with the option of a six-year extension.

contract to perform a feasibility study for a new "green" hydrogen project by the Australian hydrogen-infrastructure company Hydrogen Utility (H2U; www.hydrogenutility.com). A 30-MW water electrolysis plant, as well as a facility for sustainable ammonia production are planned to be constructed near Port Lincoln in South Australia. It will be one of the first ever commercial plants to produce CO_2-free "green" ammonia from intermittent renewable resources. The planned facility will integrate different hydrogen technologies, including a multi-megawatt electrolyzer plant and an ammonia production facility with a capacity of 50 ton/d. Both plants will be based on thyssenkrupp technology. A 10-MW hydrogen-fired gas turbine and 5-MW hydrogen fuel cell will supply power to the grid.

ODC-BASED CL_2 PLANT

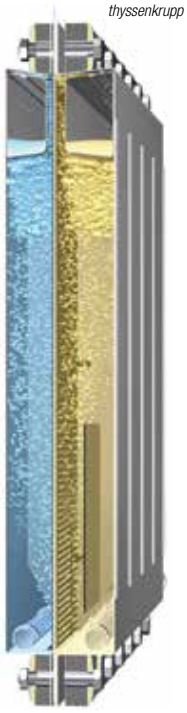
Covestro AG (Leverkusen, Germany: www.covestro.com) is planning to build its own chlorine-production plant in Tarragona, Spain. The company is investing €200 million in the plant, which will

(Continues on p. 8)

Advanced water electrolysis launched

Last month, thyssenkrupp Industrial Solutions AG (Dortmund, Germany; www.thyssenkrupp-industrial-solutions.com) launched industrial-scale water electrolysis systems that make large-scale hydrogen production from renewable electricity economically attractive. The advanced water electrolyzer (diagram) features a well-proven cell design paired with an especially large (2.7 m^2) active cell area. By further optimizing the proven "zero-gap" electrolysis technology (leaving virtually no gap between membrane and electrodes), very high efficiencies of more than 82% are achieved, says the company.

"We transferred our knowledge and experience from chlor-alkali zero-gap to the alkaline technology," explains Roland Käppner, head of Energy Storage and Hydrogen at thyssenkrupp Uhde Chlorine Engineers. "Throughout more than five years of research and development, our engineers optimized the cell architecture, current density, materials, coatings and other parameters. Since we were running full-size cells in an industrial test environment during this time, we were able to create very realistic conditions in order to achieve very precise results," explains Käppner.



thyssenkrupp

To make deployment of large H_2 projects as easy as possible, the thyssenkrupp technology is available in pre-fabricated, skid-mounted standard modules. "We designed our modules in sizes of 5, 10 and 20 MW each. The pre-mounted skid modules allow easy transport and quick installation with minimum effort. By simply adding them up, desired project sizes can easily be realized, up into ranges of several hundred megawatts," says Käppner. "A 100-MW plant would be realized with five 20-MW modules. A 20-MW module is designed for 4,000 Nm^3/h of H_2 and contains several hundred cells."

The first industrially deployed demonstration of the technology — an electrolyzer with design capacity of 1 MW — was commissioned in May for the Carbon2Chem project (www.thyssenkrupp.com/en/carbon2chem). "Compared to the full module size, this is a rather small-scale unit for our standards," says Käppner. "It uses the full cell size, but less elements/cells, so the electrolyzer stack has just been built shorter," he adds. "This site will also serve as further testing environment for green chemical value chains, which start with hydrogen and produce, for example, methanol, ammonia or other key chemicals."

Low-cost solar thermal technology to be coupled with energy storage

Sunvapor Inc. (Livermore, Calif.; www.sunvapor.net) was awarded a grant from the U.S. Dept. of Energy (DOE; Washington, D.C.; www.energy.gov) last month to scale up its Green Parabolic Trough Collector, a solar thermal technology that cuts construction costs by half compared to existing solar thermal systems. The new grant builds on the success of the prototype system (*Chem. Eng.* June 2017, p. 7). The Sunvapor collectors use a patented low-cost spaceframe structure built from lumber instead of steel to support the parabolic mirrors, and an advanced alignment process to maintain the accuracy of the parabolic assembly.

For the new project, the solar collectors will generate 150-psi saturated steam for an industrial food-production process. The solar collectors will be coupled with a thermal-energy storage technology that will allow steam generation at times of low or no sunlight. Sunvapor is working with the U.S. National Renewable Energy Laboratory (NREL; Golden, Colo.; www.nrel.gov) on the storage solution. It is based on a set of phase-change materials (PCMs) that are specifically chosen for high latent heat, a melting point tuned for the steam pressure, low cost and environmental safety.

"As the excess steam generated by the solar collectors is introduced to the heat exchanger, the PCMs melt, effectively storing the thermal energy," explains Philip Gleckman, CEO of Sunvapor. "Later, when no sunlight is present, the stored energy can be used to generate steam as the PCMs freeze." The near isothermal heat exchange reduces the mean fluid temperature in the solar field, leading to lower heat losses, higher efficiency and lower costs, he says.

Although the first deployment of the solar-steam and energy-storage system will be a food-processing application, the steam conditions are similar to those used for the most efficient desalination processes for brackish water that include heat recovery in the last distillation effect, Gleckman notes, so the platform can also be applied there in the future, as well as many other industrial applications where steam is required.

be the first industrial-scale unit based solely on oxygen-depolarized cathode (ODC) technology. Covestro and thyssenkrupp Uhde Chlorine Engineers (see p. 6) developed the ODC technology, which consumes around 25% less energy than conventional chlor-alkali electrolysis.

ODC technology is based on the conventional membrane process, in which chlorine, caustic soda and hydrogen are produced from rock salt and water. By replacing the H_2-generating electrode ODC, only Cl_2 and NaOH are produced, and the required voltage is reduced by about a volt. The technology was first demonstrated at industrial scale (20,000 m.t./yr) in Krefeld-Uerdingen, Germany in 2011 (*Chem. Eng.* May 2010, p. 11).

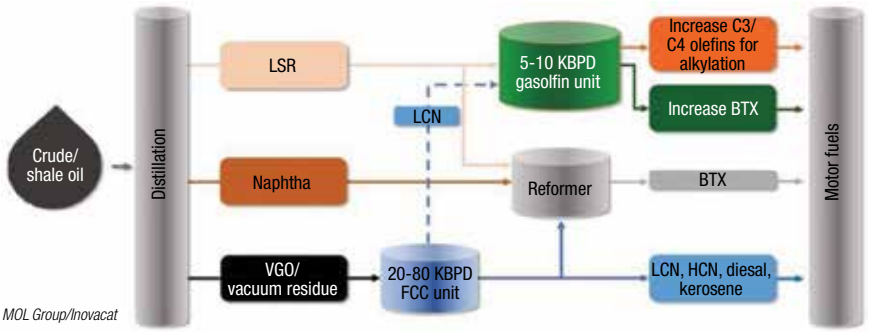
NEW CATALYST

The research group of Professor Michikazu Hara at Tokyo Institute of Technology (TiTech; Tokyo, Japan: www.titech.ac.jp) has developed flat-shaped pristine face-center cubic (fcc) ruthenium nanoparticle (NP) catalysts to produce industrially useful aromatic amines, without producing byproducts. These catalysts have a large fraction of atomically active {111} facets on their flat surfaces. The group has now extended its work by developing a new flat-shaped fcc Ru nanoparticle-based catalyst with active sites that have weak electron-donating power, which enables the highly efficient and

(Continues on p. 9)

A push to upgrade naphthas into petrochemicals

Last month, MOL Group (Budapest, Hungary: www.mol.hu) entered into a strategic partnership with Inovacat (Amersfoort, the Netherlands; www.inovacat.com) to further upscale and commercialize Inovacat's Gasolfin gasoline-to-olefins technology, which converts low-valued gasoline and naphthas into high-value propylene, butylene and BTX (benzene, toluene, xylenes). MOL Group will support the next stages of the development program of Inovacat and will investigate different options for the implementation of Gasolfin in its production facilities.



MOL Group/Inovacat

The Gasolfin technology may be inserted into almost any existing petroleum refinery (diagram) or petrochemical plant configuration. Gasolfin uses a proprietary catalytic system comprising modified zeolites tailored for the selected feedstock. The process operates at low-pressure and moderate temperature, utilizing standard processing equipment. The reactor section consists of multi-staged, fixed-bed reactors, which is optimized for cracking gasoline-boiling-range hydrocarbons immediately into propylene and butylenes. Also, the graded, mixed-catalyst bed guarantees long operating cycle times by minimizing deactivation reactions, such as coke formation, which is problematic for conventional, precious-metal and chromium-based propane-dehydrogenation processes.

This patented technology delivers propylene yields of up to 45% depending on feedstock, and can convert any light straight-run naphtha, including pentanes, says Inovacat. It is also at least 30% more energy efficient than comparable conventional processes, with CO_2 emissions being at least 25% lower. Investment payback time of a Gasolfin unit is less than 18 months, says MOL.

MOL plans to increase its non-fuel production in petroleum refining from the current 30% to 50% of total output, which will be done mostly through increasing feedstock transfer to chemicals. In order to reach its strategic goals, MOL plans to invest around $4.5 billion into its petrochemical segment by 2030, focusing mainly on the extension of the propylene value chain in the next five years.

Fuel-cell solution lowers operating costs using nanostructured catalysts

The two main barriers to widespread use of fuel cells have been securing a reliable source of hydrogen that avoids CO_2 emissions, and cost — they have traditionally depended on expensive platinum and palladium catalyst materials. GenCell Energy Ltd. (Petach Tikvah, Israel; www.gencellenergy.com has introduced an off-grid fuel-cell power-generation system that addresses these challenges. The GenCell A5 is a fuel cell with a low-cost catalyst coupled with an on-demand system for generating hydrogen gas from anhydrous ammonia, a widely accessible industrial chemical.

Designed to replace diesel generators in remote and off-grid areas, the A5 first converts ammonia into a mixture of 75% hydrogen and 25% nitrogen using a patented catalyst material with unique surface nanostructure. The hydrogen is then combined with oxygen from ambient air within an alkaline fuel cell, where electricity is produced.

"Most low-temperature fuel cells are based on acidic chemistry," says GenCell CEO Rami Reshef, "but we have developed a new nanostructured catalyst for promoting the reaction of hydrogen and oxygen that has a precisely defined chemical formula, including carbon and nickel, as well as carefully controlled nanoscale structure that avoids the need for Pt- and Pd-based catalysts."

As a result, the A5 is able to generate electric power without CO_2 emissions (and other pollutants) and to do so at operating costs that are as low as 50% of those for diesel generators, Reshef points out. Fuel for the A5 is delivered as a 12-ton tank of anhydrous ammonia, which supplies enough hydrogen for the fuel cell for one year of continued operation.

In tests conducted by GenCell, the A5 fuel cell performance matches the performance of conventional fuel cells with platinum catalysts, Reshef says. The company is currently producing the novel catalyst materials at production scale, and has recently delivered commercial models of the A5.

The commercial launch of 3-D-printed membranes

Last month, Nano Sun, a water technology start-up founded by a scientist from Nanyang Technological University (NTU; Singapore; www.ntu.edu.sg) launched a 3-D-printing facility to manufacture a new type of water-treatment membrane. Unlike conventional membrane-manufacturing processes, which use acids to make polymers porous so they can function as filters, Nano Sun uses a proprietary 3-D printer, which can print millions of polyvinylidene fluoride (PVDF) nanofibers per second. The fibers accumulate onto a backing material and are then compressed into an ultra-thin membrane sheet. By adjusting how thick or thin these unwoven fibers are layered on top of each other, the membrane can be made into microfiltration and ultrafiltration membranes. Further studies are now underway to develop improved anti-fouling additives, which can be combined with other materials during the printing process.

The resulting membrane is said to have a faster water flowrate than conventional membranes, despite having a similar pollutant-rejection rate. This property makes it possible to build smaller wastewater-treatment plants, which lowers the costs for land, infrastructure and labor. The new membrane is also said to be more resistant to breakage and biofouling than those made by conventional methods, thereby requiring less maintenance and increased cost efficiencies.

The first deployments of this next-generation membrane will be for two of the largest multinational semiconductor companies in Singapore and at a new municipal wastewater treatment plant in China, which can treat up to 20 million L/d of water.

Nano Sun's new 3-D-printing manufacturing plant is the culmination of a two-decade effort by its co-founder and NTU associate professor Darren Sun, with support from the Singapore Economic Development Board.

selective reductive amination of various carbonyl compounds. In laboratory trials for a model reductive-amination of biomass-derived furfural to furfurylamine, the new catalyst exhibits a high turnover frequency (TOF) of approximately 1,850 h^{-1}, and provides a reaction rate approximately six times higher than existing catalyst (Ru supported on Nb_2O_5), which exhibits a TOF of around 310 h^{-1}.

The Ru-nanoparticle catalyst also exhibits excellent durability and selectivity during prolonged recycling. Shape-specific Ru NPs are available as a benchmark catalyst for the efficient production of various primary amines, particularly the important biomass-based amine intermediates. The researchers expect that the new catalyst will help cut energy consumption of such reactions by one third compared to conventional supported-metal catalyzed reactions.

(Continues on p. 10)

SCR CATALYST

Last month, the Catalysis business unit of Clariant (Munich, Germany; www.clariant.com) introduced an expansion of its EnviCat series of catalysts to include a high-performance catalyst for selective catalytic reduction (SCR) to combat oxides of nitrogen (NOx) emissions. The catalyst, an extruded honeycomb structured block made from a vanadium-based composite, is designed to facilitate NOx reduction reactions in an oxidizing atmosphere. With high selectivity, EnviCat NOx significantly decreases NOx levels using ammonia as a reducing agent for the conversion of NOx pollutants into nitrogen and water. EnviCat NOx SCR has been demonstrated to effectively lower NOx emissions from gas-fired exhaust streams, and is suitable for a multitude of industrial applications, says the company.

EnviCat NOx SCR is available in module designs of varying lengths and cell densities, is easily installed and can be configured to a plant's particular dimensions. The catalyst supports to achieve plant-specific emission limit targets while effectively controlling NH_3 slip under low- to mid-temperature operation. ❑

New LEDs offer improved properties

Flexible micro light-emitting diodes (LEDs) — a sub-100-µm light source for red, green and blue light — have become a strong candidate for the next-generation display due to their low power consumption, fast response, and flexibility. The previous micro-LED technology had drawbacks, such as poor efficiency, low thermal reliability, and the lack of interconnection technology for high-resolution micro-LED displays. Now, a team from the Korea Advanced Institute of Science and Technology (Daejeon, South Korea; www.kaist.ac.kr), led by professors Keon Jae Lee and Daesoo Kim, has developed flexible vertical micro LEDs (f-VLEDs) using anisotropic-conductive-film (ACF)-based transfer and interconnection technology.

The Korean team has fabricated an f-VLED array through the precise alignment of ACF bonding. Those f-VLEDs achieved optical power density of 30 mW/mm^2) — three times higher than that of lateral micro-LEDs — and improved thermal reliability and a lifetime of 100,000 h by reducing heat generation within the thin-film LEDs.

Lee says the f-VLED can be used in low-power smart watches, mobile displays and wearable lighting. These devices are also suitable for biomedical applications, such as controlling the behavior of neuron cells and brains, phototherapeutic treatment and contact lens biosensors. In contrast to the electrical stimulation that activates all of the neurons in the brain, these f-VLEDs can stimulate specific excitatory or inhibitory neurons within the localized cortical areas of the brain, which allows for precise analysis, high-resolution mapping, and neuron modulation of brains.

Lee established a startup company, Fronics, Inc., based on micro-LED technology, and is seeking partners to commercialize the technology. ■

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Plant Watch

BASF to expand global antioxidant production capacities

July 10, 2018 — BASF SE (Ludwigshafen, Germany; www.basf.com) plans to increase the global production capacity for its antioxidant Irganox 1010 by 40% with production expansion projects at its sites in Jurong, Singapore and Kaisten, Switzerland. Expanded production in Switzerland and Singapore will start up in 2019 and early 2021, respectively. In addition, BASF is investing in its McIntosh, Alabama facility to further expand capacity.

AkzoNobel to increase production of chloromethanes in Frankfurt

July 5, 2018 — AkzoNobel Specialty Chemicals (Amsterdam, the Netherlands; www.akzonobel.com) has started design work for a second expansion of chloromethanes capacity at its site in Frankfurt, Germany. The project will take place in several steps over the next five years and will raise total capacity by up to 50%. The new expansion phase will begin with an increase in capacity for methyl chloride, to be completed in 2020.

KBR to revamp Haifa Chemicals' nitric acid plant

July 5, 2018 — KBR, Inc. (Houston; www.kbr.com) has been awarded a plant revamp contract by Haifa Chemicals Ltd. (Matam-Haifa, Israel; www.haifa-group.com) for its nitric acid plant in Mishor-Rotem, Israel. KBR will provide a complete system for the selective catalytic reduction (SCR) of nitrogen oxides, with additional catalyst beds for N_2O and NH_3 slip abatement. The SCR system will be integrated into two existing nitric acid plants operated by Haifa with capacities of 240 and 147 metric tons per day (m.t./d).

Sipchem begins commercial operation of PBT plant

July 3, 2018 — Saudi International Petrochemical Co. (Sipchem; Jubail, Saudi Arabia; www.sipchem.com) commenced commercial operations at a new polybutylene terephthalate (PBT) plant located in Jubail Industrial City. The total production capacity of the PBT plant is 63,000 m.t./yr. PBT is a specialty thermal engineering polymer used in many applications, including automotive and electronics products.

Ineos confirms €2.7-billion investment in ethane cracker and PDH unit

July 3, 2018 — Ineos (London; www.ineos.com) has approved a €2.7-billion capital project to build both a world-scale ethane cracker and a propane dehydrogenation (PDH) unit in Northern Europe. According to Ineos, this will be the first new cracker built in Europe in two decades. The project is expected to be completed within four years.

AkzoNobel to invest in second chlorine production line in Rotterdam

July 3, 2018 — AkzoNobel Specialty Chemicals plans to upgrade its chlor-alkali plant in Rotterdam, the Netherlands, by investing in a second production line for chlorine and caustic soda, and will also implement a series of other upgrades. Construction is expected to start in 2019, and the new production line is due for completion by 2021.

Johnson Matthey building demonstration plant for next-generation battery material

July 2, 2018 — Johnson Matthey p.l.c. (JM; London, U.K.; www.matthey.com) is building a demonstration-scale plant in Clitheroe, U.K. to manufacture the next-generation battery material eLNO to power electric vehicles. The new plant will have a production capacity of 1,000 m.t./yr. Work is also underway on the design of JM's first full-scale commercial manufacturing plant for eLNO, due to start production in 2021 or 2022.

Evonik to expand precipitated silica capacity in Turkey

July 2, 2018 — Evonik Industries AG (Essen, Germany; www.evonik.com) plans to increase its production capacity for precipitated silica at an existing site in Adapazari, Turkey by 40,000 m.t./yr. Startup of the new production complex is scheduled for 2020.

Linde expands manufacturing capacity for fluorine-nitrogen mixtures in Oregon

July 2, 2018 — Linde AG (Munich, Germany; www.linde.com) has expanded capacity for fluorine-nitrogen mixtures for etching and cleaning applications in semiconductor manufacturing at its site in Medford, Oregon. This allows both low- and high-pressure fluorine and nitrogen mixture production and onsite high-purity fluorine production. Furthermore, the product line is expanding to include fluorine-argon mixtures in place with tri-mix capability (fluorine-argon-nitrogen) later in 2018.

SK Advanced and PolyMirae to build polypropylene plant in Ulsan

June 27, 2018 — PolyMirae Co., a 50/50 joint venture (JV) between LyondellBasell (Rotterdam, the Netherlands; www.lyondellbasel.com) and Daelim Industrial (Seoul, South Korea; www.daelimchem.co.kr), announced that it would establish a JV with SK Advanced (Ulsan, South Korea; www.skadvanced.com). The new JV intends to build a 400,000-m.t./yr polypropylene plant in Ulsan. Construction on the project will begin in January 2019 and

commercial operation will begin in the first half of 2021.

Mergers & Acquisitions

HollyFrontier to acquire Iowa-based lubricants company

July 10, 2018 — HollyFrontier Corp. (Dallas, Tex.; www.hollyfrontier.com) entered into a definitive agreement to acquire lubricants manufacturer Red Giant Oil Co. Based in Council Bluffs, Iowa, Red Giant Oil has storage facilities in Idaho, Utah and Wyoming, along with a blending and packaging facility in Texas.

Mexichem acquires Pemex share of PMV

July 9, 2018 — Mexichem S.A.B. de C.V. (Tlalnepantla, Mexico; www.mexichem.com) reached an agreement for the acquisition of Pemex's (Mexico City; www.pemex.com) 44.09% share in Petroquímica Mexicana de Vinilo, S.A. de C.V. (PMV). The acquisition amounts to approximately $178.7 million, and occurs as PMV is refocusing its value chain on salt, chlorine and caustic soda.

Mitsubishi Chemical to acquire PVC manufacturer in Indonesia

July 9, 2018 — Mitsubishi Chemical Corp. (MCC; Tokyo; www.m-chemical.co.jp) plans to acquire 100% of the shares of PT. ABC Plastindo, a producer of polyvinyl chloride (PVC) compounds based in Tanggerang, Indonesia. With the acquisition of Plastindo, MCC will further accelerate its business expansion into the automotive and electronic-cable fields.

BASF acquires two manufacturers of 3D-printing materials

July 6, 2018 — BASF has acquired Advanc3D Materials GmbH (Hamburg, Germany) and Setup Performance SAS (Lyon, France). Advanc3D Materials offers tailor-made plastic powders and formulations for selective laser sintering (SLS). Setup Performance is Advanc3D Materials' partner in the development and manufacture of SLS materials. BASF is integrating both companies into its subsidiary BASF 3D Printing Solutions GmbH (B3DPS).

Praxair to sell European assets to Taiyo Nippon Sanso

July 5, 2018 — Praxair, Inc. (Danbury, Conn.; www.praxair.com), in accordance with its proposed business combination with Linde, has signed an agreement to sell the majority of its businesses in Europe to Taiyo Nippon Sanso Corp. (Tokyo; www.tn-sanso.co.jp) The businesses generated sales of approximately €1.3 billion in 2017. The purchase price for this transaction is €5.0 billion. Praxair and Linde continue to work diligently with the objective of closing the merger in late 2018.

Indorama to acquire PET manufacturing assets in Egypt

June 20, 2018 — Indorama Ventures Public Co. Ltd. (IVL; Bangkok, Thailand; www.indoramaventures.com) entered into a joint-venture agreement with Dhunseri Petrochem Ltd. to acquire its Egyptian Indian Polyester Co. S.A.E. (EIPET) polyethylene terephthalate (PET) facility located in the Ain Sokhna free-trade zone in Egypt. This PET plant has a capacity of 540,000 m.t./yr, allowing an uninterrupted supply of recyclable PET. The addition of EIPET will increase Indorama Ventures' existing global PET capacity by 10%. ■

Mary Page Bailey

Dechema

Achema 2018 Review

Sustainability, digitalization and flexible production approaches emerged as major themes at the recent Achema 2018 event in Germany

IN BRIEF

Attendees at June's Achema (www.achema.de) 2018 trade show for the chemical process industries (CPI) received healthy doses of information on products, technologies and ideas that, in one way or another, were geared toward three areas: increasing the sustainability of chemical processes; utilizing digital tools for efficiency, optimization and training; and implementing flexible manufacturing approaches, including modular construction. This article provides an overview of some of highlights from Achema that relate to these areas. Other emerging developments surrounding Achema were outlined by event organizers at the show's launch (see sidebar, "Achema Top Trends," p. 16).

Sustainable chemistry

Global population and demographics, combined with environmental protection challenges have been pressuring chemical processors to become cleaner and more efficient, but this Achema event placed a spotlight squarely on how the CPI must change to meet the needs of a sustainable future. A good example of this focus at the fair was the activity of the International Sustainable Chemistry Collaborative Center (ISC_3; Bonn, Germany; www.isc3.org), a think tank and multi-stakeholder platform designed to support innovation, entrepreneurship and education in sustainable chemistry. Launched last year, the organization sees itself as a "multiplier," helping innovative products reach markets and promoting new business models. The center manages a network of experts, promotes collaboration in the value chain, offers training and financial support — especially in developing countries — and carries out innovation scouting activities to discover new technologies, processes and business models, according to ISC_3 leaders.

Another example of the sustainability theme at Achema was the focus on the topic of plastics use and recycling. Although there were several forums for this topic, a panel discussion on Achema's second day (Figure 1) directly explored the challenges of making plastics more sustainable. The ideas-heavy discussion addressed the complex web of issues surrounding plastics use and recycling, including sustainable design for product packaging, consumer education and behavior, recycling logistics and others.

There was participation on the panel by representatives from a plastics trade group, an academic institute, a waste-management company and the European Commission (EC; Brussels, Belgium; www.ec.europa.eu). While several members of the panel emphasized the importance of individual behavior in changing the outlook for plastic waste in the future, the role of governments also came up. The EC representative, Hugo-Maria Schally, from the Directorate General for Environment of the EC, said that government regulations would have to play a role in changing the way plastics are manufactured, used and recycled. He described a package of initiatives from the EC, including a strategy to handle plastic waste, which has become a huge ocean-pollution problem. The European Strategy for Plastics in a Circular Economy, adopted in January of this year, is designed to foster better design of plastic products, raise plastic recycling rates and increase the quality of recyclates to support the market for recycled plastics.

Among the key strategies for addressing the challenges of sustainability of the CPI is collaboration to re-shape chemical value chains toward more sustainable models. This was the topic of a plenary lecture on the fourth day of Achema from professor Walter Leitner, of the Max Planck Institute for Chemi-

cal Energy Conversion (Mülheim; www.mpg.de), and Markus Steilemann, CEO of Covestro (Leverkusen, both Germany; www.covestro.com). Academic-industrial partnerships are critical, Leitner said, because many of the problems of sustainability are complex and interdisciplinary. But also, coupling chemical manufacturing with other industry sectors, such as power generation or steelmaking, can help use energy resources more efficiently and close the carbon cycle, said Steilemann. Covestro has been among the pioneers in exploring non-traditional feedstocks, such as plant-based materials and CO_2 from ammonia manufacturing operations, to make products more sustainable.

The award ceremony for the 2017 Dechema Prize on the last day of the conference also gave a nod to sustainability. Award recipient Timothy Noël, from Eindhoven University of Technology (the Netherlands; www.tue.nl), received the award and presented his work in using sunlight and mild conditions for driving reactions in organic chemistry. Noël and his research group have explored the use of narrow-bore flow reactors and luminescent solar concentrators (LSC) to carry out chemical reactions that traditionally have required high temperatures and aggressive reactants.

FIGURE 1. This Achema panel discussion explored the issues associated with plastics waste in Europe

Digitalization

The incorporation of digital and industrial internet of things (IIoT)-related tools into chemical process operation and monitoring has been a leading theme in the CPI over the last few years, and the trend continued at the Achema event. Many exhibiting companies featured digital

offerings, including a proliferation of augmented reality (AR) and virtual reality (VR) demonstrations for a host of applications in maintenance, training and education, and other areas. German equipment maker IKA Werke GmbH (Staufen im Breisgau, Germany; www.ika.com) and American software company Bentley Systems Inc. (Exton, Pa.; www.bentley.com) were among the many showcasing AR/VR technologies at Achema.

Another company displaying AR/VR technologies at Achema was i.Safe Mobile (Lauda-Koenigshofen, Germany; www.isafe-mobile.com), which showcased an AR tablet device that mounts to a certified hard-hat or helmet (Figure 2). Users can perform hands-free maintenance and inspection tasks, while taking advantage of the headset's capabilities, including a live-stream video feature and noise-canceling microphones for audio communications. The headset is suitable for use in hazardous environments, the company says and runs on Android software.

Beyond AR/VR, other digital tools in the Achema exhibit halls focused on data analytics and the interaction between human operators and digital systems. An example is Rockwell Automation's (Milwaukee, Wis.; www.rockwellautomation.com) Factory Talk Analytics, which is designed to provide visibility into a plant's automation system. Factory Talk incorporates a chatbot, named "Shelby," that users can query directly. The smart system is designed to learn which topics are of interest to each user and prioritizes information accordingly. A companion software system known as Factor Talk Team One allows operators to raise issues that they detect, as well as chat with each other or share photos of faulty equipment, says Rockwell.

Achema's focus on digitalization extended to a panel discussion on the third day of the show, in which experts discussed the corporate culture changes that must occur along each company's digital journey. Among the messages touched upon by the panelists were that the objective of digitalization should be to provide tangible benefits to operators, including by creating value in the user experience. Also, panelists said that by using digital tools, companies could learn more about their customers over time.

The Achema Worldwide Business Forum for 2018 also had a digital angle, but the emphasis here was not on using digital tools for process optimization, but for e-commerce. The forum showcased companies that have begun to implement strategies for establishing business-to-business (B2B) e-commerce activities in China. Because of a number of factors, including a robust mobile-phone culture, China sits at the forefront of the digital business for chemicals. Companies such as Evonik Industries (Essen, Germany; www.evonik.com) and Covestro related their experiences setting up digital sales platforms that took advantage of mobile apps widely used in China, such as WeChat. Covestro has adopted a "human-centric" model for digital business to make it as easy as possible for purchasers of chemical materials to place orders and inquire about product samples.

In a related development, Endress+Hauser Inc. (E+H; Greenwood, Ind.; www.us.endress.com) also recently launched an e-commerce platform designed to streamline customer procurement processes (www.us.endress.com/register). The new e-commerce site offers customers a personalized shopping experience for online purchases. The new site provides 24/7 access to detailed information directly on the website, for both online and offline orders, the company says. Features include the ability to access RFQs (request for quotes),

ACHEMA TOP TRENDS

Dechema (Frankfurt, Germany; www.dechema.de), the German society for chemical engineering and biotechnology that organizes the Achema tradeshows, outlined a set of "Top Trends" for this year's event, organized into seven broad categories. In the "Plant and Project Engineering" category, trends included the shale-gas-driven boom of ethylene cracker projects in the U.S., the continued movement for world-scale megaprojects in the chemical manufacturing area, as well as the trend toward modular engineering for fine and specialty chemicals. Many of Achema's Top Trends involved the industrial internet of things (IIoT) also known as "Industry 4.0". Among the trends are the use of "digital twins" in engineering, easier predictive maintenance, and the use of augmented and virtual reality (AR/VR) for training and education. Also, the list mentions the increasing use of data analytics and process simulation to boost process efficiency and optimize processes. Although the topic of bio-based chemicals remains a focus for Achema, the relatively low prices for crude petroleum are challenging bio-based processes, according to the trends list. The full list of Achema 2018 Top Trends can be found in the June 11, 2018 issue of the *Achema Daily* (https://epaper.vogel.de/process_87118), the official publication for the event.

Chemical Engineering magazine/ Mary Page Bailey

FIGURE 2. Augmented reality (AR) and virtual reality (VR) technologies, such as the headset displayed by iSafe Mobile, were spread throughout the Achema tradefair

quotes and orders all in one place. Customers now can easily add products to a shopping cart and see their own pricing details, E+H says. All transactions are available online, including all purchase documents. Users can check the status of current orders and see order history. Products can be saved in favorite lists for easy reordering and users can assign their own references to products as well, the company says.

Modular construction

Demand is growing in the CPI for customized products and facilities, and tighter construction schedules and budgets are becoming the norm. Modular-construction approaches address some of these challenges and are growing in popularity worldwide. Modular plants fit well into the Achema 2018 focal topic of "flexible production," because modular plants allow plant engineers construction advantages and greater adaptability. For example: production capacity can be increased or decreased relatively easily by adding process modules in parallel; product variations can be altered by switching out modular reactors or downstream processing units; and raw material logistics can be addressed by mobile modules.

In one presentation on Achema's fourth day, Koch Modular Process Systems (KMPS; Paramus, N.J.; www.kochmodular.com) vice president Tom Schafer, argued that modular construction approaches can make smaller, regional-scale chemical plants cost-competitive with world-scale megaprojects in certain locations. Modular construction of plants can help realize cost savings of 25–30% compared to conventionally built facilities. By locating the plant near sources of raw materials and near to customers to cut transport costs, plant economics can match megascale plants that are driven by economies of scale, he says.

An Achema booth set up by the German Electrical and Electronics Manufacturers Association, known as ZVEI (Frankfurt, Germany; www.zvei.org), brought the modular concept to the world of automation. While functional process skids and modular approaches are becoming increasingly common, the modularization of the automation system is less advanced. The integration of modular skids into a higher-level, plant-wide control system often proves to be difficult. ZVEI has been involved with the development of Module Type Packages (MTP), which are technology-independent standard descriptions of the properties and interfaces of a process module. The MTP concept organizes the automation system into an orchestration layer provided by the control system and module layer for the integrated MTPs. Each MTP allows the export significant information for a process module so it can be integrated into a wider plant automation system. ■

Scott Jenkins

A Closer Look at Pressure Relief

Understanding how to size and select pressure-relief devices is key to ensuring the safety of your facility

IN BRIEF

Pressure-relief and pressure-regulating devices serve the critical purpose of protecting facilities, people and equipment from potentially harmful, even catastrophic overpressure situations.For this reason, it's important to properly size and select this equipment to meet specific applications needs, as well as keep abreast of the latest technology advances that can help ensure the safety of your chemical process industries (CPI) facility.

FIGURE 1. Oseco's Safety Cartridge provides a fully integrated holder disk in one hermetically sealed component designed to eliminate handling of the disc, protect the dome, reduce installation time and prevent leakage

Sizing and selection

Pressure-relief and pressure-regulating devices are by no means one size fits all, so sizing and selection is one of the most challenging aspects of ensuring safety in the plant, say the experts.

"There are north of 20 to 30 variables required to size and select pressure-relief valves, including system pressure, back pressure and set pressure," explains Sean Croxford, business unit manager with Farris Engineering, a division of Curtiss-Wright (Brecksville, Ohio; www.cw-valvegroup.com/farris). "When considering the entire relief-system design and depending on the type of protected system, there could be more than a couple hundred variables to include in an evaluation. Focus must not be only on the most catastrophic scenario, but on all of the scenarios per OSHA 29 CFR 1910.119 requirements. All scenarios must be fully documented. Careful consideration should be given to document not only applicable scenarios, but non-applicable scenarios, as well."

According to Robert Owens, general manager – pressure management with Proconex, Emerson Automation's Local Business Partner serving the Mid-Atlantic Region (Royersford, Pa.; www.proconexdirect.com), customers should also be aware of the following considerations when searching for the best solution:

- *Operating temperature.* Can elastomer seats be used or are metal-to-metal seats required?

Parker Hannifin

FIGURE 2. Parker Hannifin's Cartridge Safety Relief Valves, designed to offer the highest level of protection while maintaining easy serviceability, allow for a simple and easy upgrade path to the new cartridge-based design. The cartridge-based design allows for replacement while the housing remains in the system

- *Desired operating pressure.* Will a spring-loaded valve work or will a pilot-operated relief valve be required?
- *Environmental considerations.* Is industry standard seat leakage acceptable?
- *Inlet and discharge piping design.* Does the design of the inlet piping create excessive line loss that can affect the operation of the valve? Does the discharge piping system create excessive backpressure during a relief event that will affect operation of the valve and de-rate its relief capacity?
- *Required capacity*. Does the required capacity necessitate more than one safety-relief device to safely protect the process?

Ken Kurko, director, process safety services with Fauske & Associates (Burr Ridge, Ill.; www.fauske.com), continues to explain the importance of these considerations. "The first step for our clients is deciding what overpressure scenario they want to protect the vessel against in order to determine how large the device needs to be, as well as how much flow area is required to vent the vapor, gas or liquid that is going to be relieved from the vessel. Once the proper size of the device is selected, there should be pressure drop evaluations performed on the piping leading into and out of the device. Regulations specify that the inlet pressure drop to a safety-relief valve must be less than 3% of the set pressure and, for conventional valves, the outlet pressure drop from the valve must be 10% less than the set pressure."

Other considerations when dealing with the CPI, says Gabe Wood, manager, thermal hazards testing and consulting with Fauske, include what material is being vented to the environment, because the venting of many materials, as well as the amount vented, must be reported to environmental agencies. "Often, processors want to use valves because they reclose, which means less material is vented, but in potential chemical runaway situations, a rupture disk may be the better choice because it opens to remove as much reactive material as is possible from a process vessel. For reasons such as this, a process engineer must balance environmental issues with safety decisions."

Also, runaway reactions are more likely to create two-phase flow, meaning a liquid and a gas may flow through the relief device at the same time, notes Benjamin Doup, senior nuclear and chemical engineer with Fauske. "In these potential situations, the critical velocity of the two-phase flow may necessitate an increase in the size of the relief device to prevent the vessel from being over pressurized."

Chemical applications are among the most demanding relief scenarios because they often include exothermic or runaway reactions, so it is important to select the proper size and design. Fortunately, there are multiple industry resources to assist in the design and selection of safety relief systems. The most widely used resources, according to Owens, are American Petroleum Institute's (API;

PRESSURE-RELIEF AND PRESSURE-REGULATING DEVICES: THE BASICS

Pressure-relief and pressure-regulating devices are used to protect personnel and equipment from dangerous increases in pressure in a process. "Pressure-relief devices are used to protect against relief scenarios which include, but are not limited to, control valve failure, external fire, regulator failure, overfilling and exothermic reactions," says Robert Owens, general manager – pressure management with Proconex, Emerson Automation's Local Business Partner serving the Mid-Atlantic Region (Royersford, Pa.; www.proconexdirect.com). "They are used throughout a chemical processing plant on reactors, steam distribution systems, and utility services such as plant air or nitrogen, pump discharge and boilers."

Safety-relief valves are available in two basic designs: direct spring loaded and pilot operated. Direct spring loaded valves use a spring to provide a closing force on the valve based upon a specified set pressure. Pilot operated relief valves use system pressure instead of a spring. Typically, direct spring safety relief valves should not be operated any higher than 90% of the stamped set pressure on the nameplate of the valve. By their design, pilot operated relief valves can operate much closer to set pressure, explains Owens. "In some applications, pilot-operated relief valves can operate up to 98% of the stamped set pressure," he says.

Rupture disks are also commonly used in the chemical process industries (CPI). Unlike safety relief valves, rupture disks do not reclose after a release. "Depending on the design, rupture disks can be operated up to 95% of stamped burst pressure. Many chemical processing facilities use rupture disks to isolate safety-relief valves in order to eliminate seat leakage and to protect the valve internals from corrosive media," says Owens.

Alan Wilson, senior field engineer and agency manager, with Oseco (Broken Arrow, Okla.; www.oseco.com) agrees that a combination of the two technologies is often recommended in the CPI. "You get the best of both worlds. When there's an overpressure situation and the rupture disk bursts, the relief valve also opens to relieve any excess pressure and then closes, preventing the entire loss of what is inside the process from leaking out of the vessel," he says.

The combination also serves to keep pressure-relief valves in good working order because without the disk, the valve may be exposed to corrosion and erosion from the process, which can cause pressure relief valves to malfunction, says Wilson. "The other advantage is, if you are running a process that is highly toxic or is being monitored by environmental agencies, the rupture disk prevents seat leakage of the pressure-relief valves, especially as you creep closer to set pressure," he adds. "In addition, rupture disks can help extend intervals between pressure-relief valve maintenance and cleaning."

Pressure-regulating valves are used to control either upstream pressure or downstream pressure by reducing or retaining line pressure in application. Pressure-retaining valves are used to maintain the line pressure to a set value on the valve inlet, while pressure reducing valves reduce the line pressure to a set value on the valve outlet, explains Jeffrey Sixsmith, product manager for valves and actuation with GF Piping Systems (Irvine, Calif.; www.gfps.com/us). ❑

Washington, D.C.; www.api.org) RP520 Parts 1 and 2. API Part 1 covers the types of safety relief devices, calculating for required relief capacities and sizing safety-relief devices. "It also has sample specification sheets that can assist the engineer in providing the complete information needed for a manufacturer to confirm sizing," he says. API RP520 Part 2 covers installation of safety relief devices. Topics include location, use of isolation valves, discharge piping, reaction forces and maintenance.

In addition, chemical processors should use safety-relief devices that are certified by the American Society of Mechanical Engineers (ASME; New York, N.Y.; www.asme.org). "Safety relief devices used on ASME-coded pressure vessels must carry ASME certifications," explains Owens. ASME-certified devices have gone through a certification process that includes audits of the manufacturer's or assembler's quality system and certification testing at either the National Board of Boiler Inspectors (NBBI; Columbus, Ohio; www.nationalboard.org) laboratory or another certified laboratory.

Also helpful are the software calculation tools available from most manufacturers, which help simplify the sizing and selection process, notes Curtiss-Wright's Croxford. "The sizing tools are automated and simplify the selection and sizing process. However, because there are so many other variables to consider, selecting a vendor that offers engineering design services is helpful because they specialize in understanding relief-valve systems and how pressure-relief valves perform within them. They have a deeper understanding of things like process hydraulics, backpressure and other process conditions that might need to be factored into sizing."

GF Piping Systems

FIGURE 3. Working toward simplifying installation, as well as making their valves more compact and more reliable, GF Piping Systems developed molded bodies and union connections for their pressure regulating valve lines

Recent innovations

While the basic technology behind pressure-relief and pressure-regulating devices hasn't changed much over the years, and most are currently able to attain the highest performance, manufacturers have been working on innovations that help overcome common challenges and further ensure safety.

"A lot of our customers face challenges when it comes to proper installation of rupture disks," says Alan Wilson, senior field engineer and agency manager with Oseco (Broken Arrow, Okla.; www.oseco.com). "Installation errors, such as putting rupture disks in the wrong holder or putting the holder in upside down, are not uncommon and can lead to leakage. For this reason, we've started to focus on making them easy to install and ensuring that the devices will operate properly."

Emerson

FIGURE 4. Rosemount 708 Wireless Acoustic Transmitter can be attached to downstream piping without necessitating breaking the pipe or making pipe modifications. These monitors will detect minute leakage and a pressure-relief event, as well as the length of that event, allowing chemical processors to easily calculate the amount of product that has been released

Oseco's Safety Cartridge (Figure 1) is a result of these improvements, he says. The device provides a fully integrated holder disk in one hermetically sealed component designed to eliminate handling of the disc, protect the dome, reduce installation time and prevent leakage. The intuitive design shortens the learning curve and supports correct installation. The one-piece assembly also solves issues with leaking because it follows torque specifications of the gaskets, so the force is placed on the outlet rather than on the disk. Fugitive emissions are also eliminated because the electron-beam-welded design cannot leak outside of the piping and supports regulatory guidelines.

For its safety-relief valves, Parker Hannifin (Cleveland, Ohio; www.parker.com) also developed a cartridge system to simplify installation and maintenance. The company's Cartridge Safety Relief Valves (CSRV) (Figure 2) are designed to offer the highest level of protection while maintaining easy serviceability. The device was designed from the company's existing safety-relief valve housing, which allows for a simple and easy upgrade path to the new cartridge-based design. The cartridge-based design allows for replacement while the housing remains in the system. "It is required by code to replace safety relief valves every five years or after a release, so this type of periodic maintenance is greatly simplified with a cartridge base," says Andrew Stock, product manager with Parker Hannifin's Industrial Refrigeration Division. "It is a quick changeover that doesn't require altering the piping of the system. Users simply unscrew the cartridge, replace it with a new one and put the changeover valve back in the right position. Instead of hours of work with a pipe fitter, this can be done in a matter of minutes with no special tools or changes to the piping system."

For its pressure-regulating valves, GF Piping Systems (Irvine, Calif.; www.gfps.com) is also working toward simplifying installation, as well as making their valves more compact and more reliable via the use of molded bodies and union connections. While most pressure-regulating valves offer threaded connections, union connections allow users to easily install and remove the valve from the system. The compact design allows installation even when space is limited and the integrated assembling aid enables direct assembly of the valves to mounting sets. "With this design, the entire inner workings are in a self-contained unit, called the cartridge, and the housing is the body. This allows users to easily take the valve out and exchange it with another so they can perform maintenance, reducing time," notes Jeffrey Sixsmith, product manager for valves and actuation with GF Piping Systems. "In addition, the housing is interchangeable between pressure retaining and reducing valves, so it is only necessary to stock the valve cartridges. You can change the valves from downstream control to upstream control using the same housing."

The recent approval of restricted lift options for pressure-relief valves under ASME Code Section VIII and API 526 has led Curtiss-Wright's Farris Engineering division to offer restricted lift on its 2600 and 2600L Series API-type pressure relief valves. The restricted lift option is available on orifice sizes D-Z for compressible service for both new 2600 Series valves and as a retrofit option for Farris' in-service valves. The benefit of using restricted lift, according to the company, is that operators can more closely match the pressure-relief valve's flow capacity to the systems' required capacity. Restricted lift can improve valve performance and stability, especially in larger orifice size valves. Pressure-relief valves with a restricted lift option are also a cost effective solution where pressure relief valves experience inlet pressure losses in excess of 3% of set pressure. "Restricted lift valves reduce the valve's maximum relieving capacity, which reduces the frictional losses associated with piping hydraulics, as the piping losses are calculated based on the valve maximum relieving capacity," explains Croxford.

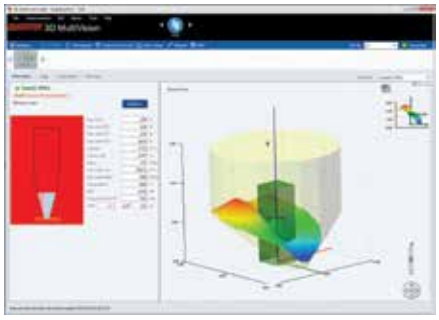
Monitoring installed relief devices is another industry trend, says Proconex's Owens. "The EPA [U.S. Environmental Protection Agency (Washington, D.C.; www.epa.gov)] and state departments of environmental protection are demanding that facilities report releases to flare or to the atmosphere. Reportable releases can result from safety-relief valves lifting to relieve an overpressure event or from leakage across the seat of the valve during normal operation," he says.

The monitoring technology that appears to be gaining traction is wireless acoustic monitoring, Owens says. "Acoustic monitors, such as the Rosemount 708 Wireless Acoustic Transmitter, can be attached to downstream piping without necessitating breaking the pipe or pipe modifications. These monitors will detect minute leakage and a pressure-relief event, as well as the length of that event, allowing chemical processors to easily calculate the amount of product that has been released." Another benefit to the technology is that it can provide an early sign of problems with the valve, allowing the processor to quickly identify and fix the issue. ■

Joy LePree

Focus on Software

Seeq



BinMaster

Software enables interactive analytics on collected data

This company recently updated its Seeq R20 advanced-analytics solution (photo) for engineers and scientists working in process manufacturing. The software application now offers expanded machine-learning functionality for users carrying out predictive analytics, and an improved query model for customers bringing in contextual data from data sources, to enable faster connections among data sources. Target markets include oil-and-gas, pharmaceutical, chemical, energy, mining, food-and-beverage and other chemical process industries (CPI) segments. Seeq R20 also includes new integration support for Inductive Automations' Ignition SCADA system, including integrated display window capabilities, says the company. — *Seeq Corp., Seattle, Wash.*

www.seeq.com

Level-scanner software guards against silo collapse

Uneven loading of bulk solids stored in silos can cause the steel and concrete walls of silos to crack, dent, buckle and bend, potentially leading to catastrophic collapse. The 3DLevelScanner includes a new software option (photo) that can identify the location of the center of gravity of the bulk solids (based on material topography), display it graphically and alert the operator when the center of gravity moves beyond an accepted, user-defined area. A 3DLevelScanner device is mounted on the roof of the silo at an optimal location to view the material surface inside the silo during operations. This system can help operators to reduce structural stress and reduce uneven loading when when filling or emptying a silo. — *BinMaster, Lincoln, Neb.*

www.binmaster.com

Use machine learning to improve asset performance

The Aspen Edge Connect and Aspen Cloud Connect family of software solutions helps process operators to support assets and infrastructure that are connected via the industrial internet of things (IIoT), bringing improved analytics and machine-learning capabilities to asset-intensive companies within a connected environment. Aspen Cloud Connect is server-based and supports a wide range of communication protocols. The system collects, cleanses and analyzes data from historians, data lakes and other data sources, integrates with process, equipment and enterprise data via AspenONE Manufacturing Execution (MES) and Asset Performance Management (APM) software, to support sustainable application developent and deployment, and these capabilities can be scaled from pilot-scale operations to commercial-scale production, says the company. — *Aspentech Technology, Bedford, Mass.*

www.aspentech.com

Comprehensive package eases turbomachinery design

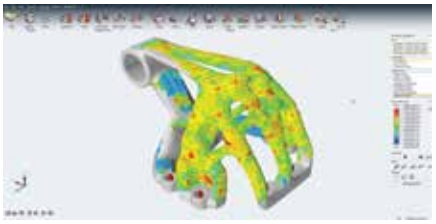
TurboTides Turbomachinery Design software supports all steps of system design in the turbomachinery-design process, from thermodynamic cycles through computational fluid dynamics (CFD) and finite element analysis (FEA), while offering user-friendly integrated optimization and knowledge management. It can be used to design centrifugal, mixed-flow and axial compressors, turbines, fans, blowers and pumps for virtually any application. The program is built to handle single-stage and multi-stage turbomachinery, including thermodynamic cycle design and optimization capabilities, supporting key decisions related to the power balance between compressor and turbine in a turbocharger, or the pressure-ratio split in a multi-stage air compressor. — *TurboTides, Inc., Lebanon, N.H.*

www.turbotides.com

View and query model data in a web-based interface

OpenPlant Connect Edition uses the company's iModelHub cloud ser-

Altair Engineering



vice, to support collaborative 2-D and 3-D plant design and operations using cloud-based data management capabilities. This software solution gives owner-operators and engineering, procurement and construction personnel the ability to design and manage their data through cloud-based services, supporting reliable and asynchronous project visibility, says the company. The iModelHub tracks all changes made to project designs and notifies users of changes. Participants can choose to synchronize to and from particular timeline milestones, and can visualize, summarize, analyze and interpret the impact of ongoing changes, says the company. — *Bentley Systems, Exton, Pa.*
www.bentley.com

Design software helps to optimize product innovation

Inspire 2018 simulation software (photo) is used to optimize product design and optimization. The product is said to integrate well into large manufacturing enterprises, and provides rapid simulation capabilities that help designers to explore weight-reduction opportunities during product design. It has an intuitive user experience that is ideal for small- and medium-size businesses that have little or no simulation experience, says the company. The software can be applied both at the beginning of "clean-sheet" design programs, and during ongoing design exploration of current production parts. It allows designers and engineers to rapidly assemble and simulate dynamic mechanical systems to automatically resolve loads on system components (for analysis and optimization), generate weight-efficient design proposals, and simulate the performance of competing design concepts with regard to static loads, normal modes and buckling. — *Altair Engineering, Inc., Troy, Mich.*
www.altair.com

A paperless way to streamline and improve calibration

The intuitive multi-platform mobile paperless CMX Calibration software is an online solution for executing and documenting calibrations and maintenance inspections. It is used to calibrate weighing instruments, analytical instruments for pH and humidity and more, says the company. It can be used in an offline mode, as well, with Beamex Documenting Calibrators. The latest version (bMobile 2.0) is available for Windows Mobile or Android-based tablets and smartphones. — *Beamex Oy Ab, Pietarsaari, Finland*
www.beamex.com

Engineers and designers can now use CAD on the go

CorelCAD Mobile is a standalone computer-aided drawing (CAD) experience designed to complement the CorelCAD 2018 desktop application for both Windows and Mac systems. CorelCAD Mobile subscribers receive a full set of 2-D drawing and editing tools, 3-D viewing tools, advanced annotation capabilities and more. For users looking for a lighter feature set, a free version is also available with simplified capabilities, including 2-D and 3-D .dwg viewing and basic annotation. CAD experiences to view, create, edit and share 2D technical CAD drawings. The product is now available for use on both iOS and Android smartphones and tablets. This boosts productivity on the go and in the field. Using the system, engineers can edit and share drawings and designs between desktop and mobile applications, which helps to make meetings with colleagues and clients more efficient and productive, says the company.— *Corel Corp., Ottawa, Ont.*
www.corel.com

Turbomachinery-design software adds new features

The version 6.4 update of the TURBOdesign Suite provides new features and added functionality to enable designers to produce highly optimized designs in a more streamlined fashion. The update, according to the company, expands the software's functionality by adding a flexible new geometry-parameterization capability (which allows the user to create arbitrary meridional geometries with arbitrary levels of control) and a new TURBOdesign integration module with Link-CCM+ (which enables the seamless integration of STAR-CCM+ into TURBOdesign Optima by leveraging the capability of TURBOdesign 3DLab to export high-quality CAD mod-

els. The software also includes TURBOdesign 3DLab, a new export of flow domains capability that lets users generate and partition flow domains and facilitate the preparation of the geometry for import into their desired CFD tool when running an optimization case with TURBOdesign Optima and 3DLab with either TURBOdesign Link-CCM+ or ANSYS Workbench.— *Advanced Design Technology, London, U.K.*
www.adtechnology.co.uk

Software enables intelligent 3-D plant design and modeling

CADWork Structure 2018 (photo) is an integrated CAD modeling structural-design software program. Recently added, easy-to-use enhancements give structural designers and engineers intelligent drawing capabilities and advanced levels of automation. The most recent enhancements include new steel and concrete modeling commands, shape-modeling enhancements, import-export tools and enhancements for modeling shapes, detecting clashes, placing spiral stairs, creating drawing templates and more. This tool allows structural designers and engineers to start modeling right away with its ready-to-use steel and concrete catalogs and assembly templates. The software's fast processing and highly refined user interface empowers users to work efficiently together on both large and small projects, says the company. — *CADWorx & Analysis Solutions, part of Hexagon PPM, Houston*
www.hexagonppm.com

Keep close track of equipment operation for improved results

The modeling, supervision and remote-control solutions developed by this company combine sensors and software to collect information from machines, and provide detailed reporting of all functions and required intervention, providing data in realtime and storing all the information so it is available in customized reports, listings and graphs that are easy to see and easy to customize. An internal system of alarm management can be completely personalized to user or government agency requirements. These products and solutions are compatible with "Industry 4.0" standards, and are compatible with other systems to gather and centralize data related to production processes and their daily activities, says the company. — *CapTemp USA LLC, Windham, N.H.*
www.captemp.com

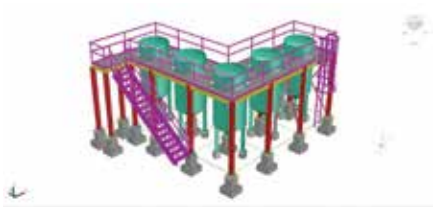
Software integrates three water-treatment technologies

Water and wastewater treatment typically involves the use of many treatment technologies to achieve the desired water quality. Optimizing the treatment train can be challenging. The Dow WAVE (Water Application Value Engine) design software integrates three technologies — ultrafiltration (UF), reverse osmosis (RO) and ion exchange (IX) — into one comprehensive tool using a common interface. It is said to simplify the multi-technology design process and ultimately help to reduce the time it takes to design site-specific water-treatment systems. WAVE upgrades the best feature's of the company's older, single-technology design software (ROSA, UFLOW, IXCALC and CADIX), while bringing all of these technologies together under one common user-friendly and time-saving interface, and can estimate the performace of UF, RO and IX technologies in water-treatment systems, either individually or in various combinations. The benefits of integrating these three technologies include improved algorithms, true mass balance volumes and flows that reflect changes in density due to temperature, water composition and water compressibility, consistent hydraulic constraints and regeneration parameters, harmonized data management, improved case management and more. — *Dow Water & Process Solutions, Edina, Minn.*
www.dow.com/wave

Protect assets and IT systems from security threats

Using its expertise and several Vulnerability and Software Asset Manager (SAM) solutions, this company provides a standardized, three-pronged approach to help chemical process operators to reduce risk by managing IT security vulnerabilities associated with software and cloud services (in-

CADWorx & Analysis Solutions

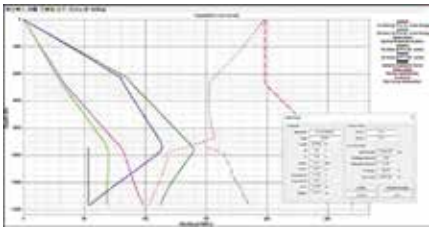


Micro-Measurements

cluding the documented Spectre and Meltdown processor vulnerabilities, which are pervasive and potentially harmful, according to the company). The system helps to determine risk criticality using verified vulnerability intelligence, prioritize remediation of known vulnerabilities based on criticality, and apply patches using a conservative mitigation approach that places an emphasis on testing in controlled environments. — *Flexera, Itasca, Ill.*
www.flexera.com

Software eases strain-data acquisition and calibration

The StrainSmart 9000 dynamic data-acquisition software (photo), launched to support the company's resistive-foil sensors for high-precision strain and high-stress measurements, allows for the simultaneous sampling of up to 48 channels, at speeds of up to 50,000 samples per second. It offers easy setup and minimal-to-no downtime, says the company. This allows it to perform accurate, realtime data recording, analysis, display and export within just minutes of software setup, with one-touch autobalance and post-processing data filtering. Channel settings within StrainSmart 9000 are performed automatically from sensor properties, largely without manual intervention. Sensor-specific input assignments associated with various strain gages, thermocouples and other sensing types helps to ease mathematical data manipulation. Signal-visualization algorithms within the system provide full graphical representation of channel assignments, for reduced potential connection errors. — *Micro-Measurements, Malvern, Pa.*
www.micro-measurements.com



Mohawk Energy

Pentair Thermal Management

Advanced digital capabilities improve wet-grinding systems

The SmartPro suite of solutions provide improved process control for the company's wet-grinding systems. SmartPro Cockpit uploads data into a high-security cloud, allowing seamless data access anytime from any location. To ensure traceability, all data are linked to a manufacturing batch identification. SmartPro Statistics detects changes of defined parameters, which alerts operators if the process performance deviates beyond the target window. The system either creates an alarm messege or adjusts single or complete sets of parameters to optimize production. SmartPro Optimization uses optimization algorithms to help operators assess and manage product properties, such as quality (for instance, particle-size distribution, viscosity and more), and allows the behcnhmarking of processes, machine locaions or even industry competitors. — *Bühler Group, Uzwil, Switzerland*
www.buhlergroup.com

Software advances target downhole design and operation

Working in partnership with Innova Drilling and Intervention, this company offers analysis software to support safe effective drilling, wellhead and rig management. The company's existing tools, Openhole and ReFrac Liners, are already widely used to monitor and manage in-situ performance of the company's expandable tubular technology, drill strings, liners and casing under wellbore loads (photo). Meanwhile, Innova's software offerings allow for realtime analysis of deployment loads, horizontal liner shrinkage, and management of three drilling strings in operation. — *Mohawk Energy, Houston*
www.mohawkenergy.com

Improved software supports heat-tracing operations

The Raychem XPI-F is the latest addition to this company's XPI polymer-insulated resistance heat-tracing cables (photo), which are developed to provide freeze protection and temperature maintenance in hazardous environments on long-line applications. This product includes Raychem TraceCalc Pro design software, which provides a step-by-step guide to choosing the best heat-tracing solution to meet the site-specific requirements. The software also provides heat-tracing system design data, such as pipe heat loss, number of circuits, electrical loads, maximum sheath temperatures and more, while providing automated heating cable and component selection solutions. — *Pentair Thermal Management, Leuven, Belgium*
www.pentairthermal.com ■

Suzanne Shelley

New Products

Glatt

Combining high-shear granulation with a fluid-bed dryer

The patent-pending TwinPro system (photo) unites two previously separate processes — high-shear granulation and fluid-bed drying — in a continuous batch process. Removing wet sieving and product transfer eliminates a critical step, which results in significantly less process time and simplified cleaning, says the manufacturer. Because it fuses these two processes for the first time, the TwinPro is optimized for total-containment applications, thanks to a significant minimization of material loss. Processes are about 20% faster compared to a classic batch-granulation line, according to the manufacturer. The closed system is shock- and pressure-resistant up to 12 bars and offers reliable protection against dust explosions and in applications with hybrid mixtures. — *Glatt GmbH, Binzen, Germany*

www.glatt.com

Van Tongeren America

Separate dry particles by size using less water

This company has introduced a line of classifier systems (photo) that collect and separate dry particles by size range using only ambient air and gravity. Allowing the material to be kept dry upstream and downstream, these air-classifier systems eliminate the use of water, replacing wet processing with a dry-processing approach that conserves water. Settling ponds to manage wastewater and costly drying equipment for moisture removal upon delivery are also eliminated. Suitable for processing salt, potash, fertilizer, fly ash, alumina, manufactured sand, diatomaceous earth and a diverse variety of minerals, aggregates and other materials in continuous operation, the classifier line comprises three different models, based on classification method: a gravitational classifier; a gravitational-inertial classifier; and a centrifugal classifier. The classifiers may be used in series to split-feed multiple products at different cut points, and often include a cyclone or baghouse dust collector to meet pollution-control requirements. — *Van Tongeren America LLC, Lebanon, Pa.*

www.van-tongeren.com

Magnetrol International

Radar level measurement for smaller process connections

The Pulsar Model R86 non-contact radar transmitter (photo) provides level-measurement performance with a smaller-wavelength 26-GHz radar signal, which results in smaller antennas and improved resolution. This is an important distinction for some process vessels because the smaller beam angle allows for installation into process connections as small as 1.5 in. (38 mm). Automated echo capture conveys realtime waveform and trend data. In addition, the event history displays up to 20 events, including diagnostic and configuration data, to pinpoint issues. The Pulsar Model R86 uses circular polarization, which eliminates the need to rotate the antenna orientation during commissioning. This simplifies installation and delivers proper alignment. High-temperature antennas are designed for use in operating conditions up to 750°F. Nozzle extensions ranging from 12 to 72 in. accommodate nonstandard nozzle lengths and buried vessel standpipes. — *Magnetrol International, Aurora, Ill.*

www.magnetrol.com

GEA Group

A large rotary lobe pump for sensitive products

This company is expanding its Novalobe pump range with the large-volume Novalobe 60 (photo), which has a chamber volume of 2.1 L per revolution. The rotary-lobe pump is specifically designed for pumping and dosing highly viscous media with large particles (up to 41 mm in diameter). This new development meets the hygiene standards for aseptic and sterile applications in the pharmaceutical, chemical and food industries. The new pump handles larger quantities at low speeds, which is crucial for sensitive media. The internal mechanical seals can be replaced from the front of the pipeline without removing the pump. These seals are optimally lubricated and cooled to significantly extend service life. Hygienic cleanability and sterilization are ensured with the choice of seals, extremely fine-pored surface quality and complete drainability in the vertical position. — *GEA Group AG, Düsseldorf, Germany*

www.gea.com

Graphite rupture discs provide long temperature resistance


Rembe

The GRX graphite rupture disc (photo) has been developed for processes with corrosive media, low pressure and temperatures between –180 and 1,500°C. The GRX is available with a synthetic resin coating (for process temperatures up to 200°C), as well as the PyC coating, developed specifically for the GRX (for temperatures above 200°C). With the PyC coating, the rupture disc holds significantly longer at very high temperatures, while remaining permanently leak-tight, says the company. Rupture discs with a coating made of synthetic resin would no longer be able to offer this leak tightness at temperatures far above 200°C. With an operating pressure ratio of up to 90% and burst tolerances of ±5%, the GRX is usable for rupture pressures from 0.02 bars. Optionally, a vacuum support can be integrated, which is installed without adhesive (which may melt at very high temperatures). The GRX is also available with a burst indicator, upon request. The installation occurs directly between the flanges. The GRX is suitable for installation in reactors, tanks, glass containers and more. — *Rembe GmbH, Brilon, Germany*
www.rembe.de

IP65- and IP66-protected HMI devices for monitoring and control

This company has extended its family of all-around protected HMI (human-machine interface) devices for machine-related, cabinet-free visualization and automation. Simatic Thin Client PRO operator terminals (photo) with 15-, 19- and 22-in. screen sizes and IP65 degree of protection are new to the range. Like all devices in the PRO series, the new Thin Client products can be extended with mountable components.


Siemens

New expansion options are operator controls with USB interfaces and an extension box with adjustable handles for easy operation of the panels on the machine. The IP66-protected Simatic HMI Thin Client Ex OG is the new addition to the series of Ex HMI devices. It can be used in 1/21 and 2/22 zones without any special measures, such as elaborate enclosures or additional certifications. — *Siemens AG, Munich, Germany*
www.siemens.com

SIL3 certification for this diagnostic controller

The partial-stroke function of the EHPC210 diagnostic controller (photo, p. 30) is now certified to Safety Integrity Level (SIL) 3 according to IEC 61508: 2010 Parts 1–7.

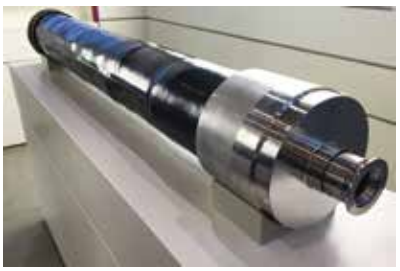
For details visit adlinks.chemengonline.com/70309-28

For details visit adlinks.chemengonline.com/70309-02

Bifold Fluidpower

Haver & Boecker

Hosokawa Alpine



Evonik Industries

The EHPC210 is a smart controller solution operating a single solenoid for partial-stroke testing in pneumatic and hydraulic valve actuation. It is designed to meet the basic requirements to perform a partial-stroke test and to record the results. The controller can interface with a valve switchbox, or has the added benefit of integral position feedback. The EHPC210 can be retrofitted onto existing systems to allow partial-stroke testing to be performed. The controller incorporates graphically displayed rotary feedback measurement, low power modes and emergency shutdown (ESD) monitoring and control. The enclosure assembly allows installation in Zone 1 or Zone 2 hazardous areas. The controller features HART and Modbus communication, as well as fully configurable control logic, allowing hard-wired interface to a local control panel or a user's control system. — *Bifold Fluidpower Ltd., Greater Manchester, U.K.*
www.bifold.co.uk

Improved packaging efficiency through smart monitoring

The Quattro monitoring system (photo) delivers performance data, reports deviating values and makes processes and service easier to plan. To use Quattro system monitoring, the machine is equipped with a router. The data collected from the system are sent to the Cloud via an encrypted connection. The visualized production and maintenance information can be accessed remotely via a computer, tablet or mobile device. Thus, personnel can access the realtime system performance data and the curves for the past hours and days, allowing rapid detection of possible performance decreases. This also makes upcoming service easier to plan. With the help of Quattro system monitoring, companies can take precautions against unforeseen downtime. — *Haver & Boecker, Oelde, Germany*
www.haverboecker.com

New and flexible solutions for coarse grinding

The multi-purpose crusher MPC 150 (photo) offers three common grinding processes in module form that can be fitted onto a basic unit: a conical mill for soft to medium-hard materials; a flake crusher for brittle materials that crush easily; and a hammer mill for solid materials that are difficult to crush. These modules for all three processes can be quickly exchanged with only one tool. In addition, the modules are very easy to dismantle and clean — there are no threads or screw heads installed in the sections that come into contact with the product. Dependent on the grinding process, the size of available screens ranges between 0.3 and 20 mm. Especially in the extremely fine particle range, these screens offer application possibilities that were rarely possible before, says the manufacturer. As a function of the mill type, the peripheral speeds range between 1 and 60 m/s. Most applications are operated in the range between 1 and 20 m/s. — *Hosokawa Alpine AG, Augsburg, Germany*
www.alpine.hosokawa.com

Gas-insulated switchgear for applications up to 38 kV

The CBGS-0 is a gas-insulated switchgear with a solid dielectric busbar for applications up to 38 kV, 2,000 A and 31.5 kA. The CBGS-0 has been designed to meet the needs of indoor substations in many industrial sectors, including water and wastewater, mining, chemicals, petrochemicals, utilities, wind farms, data centers and more. The CBGS-0 is designed for improved operator safety, and includes a grounded and shielded solid-insulated bus system installed in the top rear part of the switchgear. This means that no gas handling is required during installation, expansions or section replacement. A shielded solid insulation and sealed-for-life gas tank protect the medium-voltage components from dirt, dust and more. CBGS-0 switchgears are also designed to reduce maintenance and downtime and reduce floor-space requirements by up to 60%. — *Schneider Electric, Andover, Mass.*
www.schneider-electric.com

A new membrane for natural gas processing

Sepuran NG (photo) is a hollow-fiber membrane based on a high-perfor-

mance plastic that can withstand extreme pressures and temperatures. This enables selective separation of sour gases from natural gas, with a high tolerance of higher hydrocarbons contained in the natural gas and consistently high performance of the membrane throughout its lifetime. It features significantly increased recovery of methane, which has a corresponding effect on the profitability of natural-gas processing plants. The modular structure of Sepuran NG has been designed for conventional, membrane-based natural-gas-processing plants so that during the membrane exchange, no further adaptations are required to the existing equipment. It can be used particularly effectively in natural gas sources with a high concentration of CO_2 because, under these conditions, the separating properties of the membrane remain intact. — *Evonik Industries AG, Essen, Germany*

www.evonik.com

A new series of Atex-certified gas compressors

Pneumofore

New K Series gas compressors (photo) provide a rotary-vane solution for gas treatment and processing applications. With 2.5 to 10 bars(g) pressure and up to 2,690 m^3/h capacity, the K Series' sturdy design meets stringent safety criteria. Moreover, these gas compressors are certified for extreme and explosive environments according to the Atex directive for Zone 1 (Atex II 2/2G). Their low rotation speed guarantees longevity and low vibrations, with significant benefits in terms of safety and a low-noise working environment. Their simple design, with few moving parts, ensures reliability and reduced operational cost. K Series gas compressors handle a wide range of gases, including methane, ethane, CO_2, N_2, biogas and natural gas. Each K Series compressor is designed according to the specific gas composition and application. — *Pneumofore S.p.A., Rivoli, Italy*

www.pneumofore.com

Digitalized pneumatics replace components with apps

Festo

The new pneumatic Motion Terminal VTEM (photo) features applications (apps) that can replace over 50 individual components. The new method of function integration — combined with software apps — will simplify the value chain, since only one piece of hardware will be required. Piezo technology, integrated stroke and pressure sen-

Brabender Technologie

K-Patents

B&W Tek

sors come together with motion-control apps. Changes in pneumatic functions and adaptations to new formats are controlled via apps by changing parameters. The integrated intelligent sensors for control, diagnostics and self-learning tasks will eliminate the need for additional components, according to the manufacturer. — *Festo AG & Co. KG, Esslingen, Germany*
www.festo.com

These belt feeders have a new hygienic redesign

This company has completely redesigned its weigh-belt feeder to be more hygienic. The belts now feature PETG (copolymer of polyethylene terephthalate, PET and ethylene glycol) windows so that operators can perform unobstructed visual checks of bulk-material flow at any time. The blue seals and bearings are made of plastic material that complies with E.U. Regulation 1935/2004 and the U.S. FDA standard for plastic components. The top and front faces are housing sections that can be removed for direct operator access. For cleaning, maintenance access and dismantling of the belt, no special tools are required. The belt tensioner can be locked in a raised position to enable the untensioned belt to be easily removed. All components are now wet-cleaning-compatible. All metal components are made of stainless steel, including the load cell, which has an IP67 rating. The stainless-steel terminal box is separated from the housing by a spacer. The aseptic motor does not have cooling fins or a fan, thereby meeting hygienic standards. — *Brabender Technologie GmbH & Co. KG, Duisburg, Germany*
www.brabender-technologie.com

Inline measurement of liquid concentration and density

This company's Platform 4 digital process refractometer system (photo) consists of a probe or compact refractometer and a graphical user interface. The refractometer is a standalone device that is capable of operating independently to provide inline measurement of liquid concentrations, liquid density and more. It has a measurement range of 0 to 100% and it provides an Ethernet or 4–20-mA output signal proportional to the temperature-compensated concentration value for realtime process control. Different user interface options range from a rugged, multichannel, industrial computer to a compact lightweight and web-based version. The measurement is based on this company's technology, which uses solid-state optics and a charge-coupled device (CCD) camera to provide a digital measurement of refractive index. The measurement accuracy is ±0.0002 refractive index (RI), which corresponds to ±0.1% by weight, and is not affected by bubbles, particles or the color of the process liquid, says the manufacturer. Special wetted-parts materials and intrinsically safe and hazardous area certification are available. — *K-Patents Oy, Vantaa, Finland*
www.kpatents.com

Identify chemicals anywhere with this handheld Raman analyzer

TacticID-1064 is a new handheld Raman analyzer for realtime identification of unknown substances in the field. The TacticID-1064 is said to possess the ability to identify more samples with better accuracy and faster speed than similar Raman devices. It is based on an advanced third-generation 1,064-nm technology, providing improvements in fluorescence elimination, lower detection levels and faster response time. It also allows for safe and direct measurement of dark substances. The TacticID-1064 has a large and comprehensive onboard library included, but also allows users to create and import customized libraries. The system comes equipped with a built-in camera to capture photos at the scene to be included in the test report, which can be exported directly onto a USB drive for convenience. The TacticID-1064 displays both GHS and NFPA 704 chemical safety information, providing additional actionable data. — *B&W Tek, Newark, Del.*
www.bwtek.com ■
Mary Page Bailey and Gerald Ondrey

Maintaining heat-transfer-fluid quality

Department Editor: Scott Jenkins; text for this edition authored by Conrad Gamble, Eastman Chemical

Effective and efficient process operation requires reliable temperature control. This imposes strict demands on the management of the heat-transfer-fluid (HTF) system. This one-page reference provides suggestions for proper maintenance of heat-transfer fluids. Design features necessary to properly maintain acceptable fluid quality can be found in Table 1.

TABLE 1. DESIGN FEATURES FOR HTF SYSTEMS

Feature	Notes
Design reviews	Should be done both for the initial design and prior to system modifications to ensure process and personnel safety
Piping design	Should provide adequate flexibility to avoid excessive torque applied to flanged connections. Use fire-safe gasket materials and follow applicable codes for chemical plant piping
Venting capability	To support removing excess moisture (from hydrostatic testing of new systems) and low-boiling thermal degradation products, the fluid must be able to recirculate through the expansion tank at temperatures above 100°C while venting to a safe location
Inert gas blanketing	Protects against fluid oxidation
Sloping of installed piping	Facilitates fluid drainage following hydrostatic testing of new systems, as well as supports complete fluid replacement
Filtration	Aids in removal of insoluble solids, which can increase pump-seal wear and surface fouling in severe cases. Consider side-stream filter installation, 1 to 2% diverted flowrate, and a 10- to 20-micron cutoff
Sample port	Should be provided at a point of good circulating flow where representative sample collection can be safely performed
Sampling routine	Recommended annually when operated within 50°F (28°C) of the HTF's maximum bulk temperature rating
Documentation	Provide as-built documentation of system components and key contact information for manufacturer representatives for accurate and readily accessible information
Key indicator monitoring	Provide instrumentation with established alarm/interlock set points for expansion tank high-low liquid level, system overpressure protection, heater inlet/outlet indicators of flow, temperature rise, pressure drop on each coil/pass, and stack gas temperature. Consider utilizing periodic infrared-image monitoring of coil "skin" temperature readings or other recommended items from the heater manufacturer

Fluid selection

A critical parameter of HTF quality is thermal stability, so ensure that the fluid is rated for use up to or above the maximum temperature of operation, keeping in mind the potential for higher-temperature operation in the future. Consider selecting a fluid with excess temperature rating for handling the rigors of stressful service — such as frequent startups (such as in batch processing) where temperature controls may permit high-temperature excursions, or in periods of process upsets — so that the fluid can be more forgiving in times of high stress. Second, consider heat-transfer efficiency at the designed operating temperature. This requires evaluation of the expected relative performance of the fluids for heat transfer coefficients, pumping energy costs and ease of handling (for example, metallurgy and area electrical classification). Third, consider potential implications if the HTF mixes with process fluid as a result of leaks. Will a chemical interaction result? How easy would it be to separate the two fluids? Finally, it is prudent to review the fluid selection with the facility's insurer, in case installed-cost factors might differ among fluid options.

Avoid fluid oxidation

Any organic HTF operating at elevated temperatures can be vulnerable to oxidation. Some fluids that typically operate at medium temperatures come with additives designed to sacrificially protect the HTF until they are depleted. These consumed additives can contribute to sludge formation, which can lead to plugging of small-diameter tubing, as well as pump seal failure, corrosion, fouling and deterioration of heat-transfer efficiency.

Use of inert gas blanketing of the system applied at the expansion tank can protect the fluid against oxidation by providing an oxygen-deficient atmosphere. This helps to prolong efficient fluid life. Blanketing requires a pressure-regulated source of oxygen-free inert gas, such as nitrogen or natural gas.

A secondary source of fluid oxidation can occur if hot fluid is drained and later returned into the system. It is best to prepare job plans to allow the fluid to adequately cool prior to draining. This both protects the fluid and prevents thermal burns on workers.

High-temperature excursions

A common threat to HTF life is high-temperature excursions. Fortunately, the locations and causes of these excursions can be anticipated and addressed in the design and operating controls. The source of high temperature will be within the heat source, whether it is fuel-fired, electric heat, or perhaps a high-temperature waste-heat recovery unit. With heaters, ensure that the fluid maintains fully developed turbulent and uniform flow through heater coils or across heating elements to convey the heat flux away from the coils and element wall.

Common causes of these excursions include pump cavitation, reduced flowrates, changes in fuel, power failures and changes in flame patterns. New HTF systems should have a comprehensive set of critical parameters established to monitor for good operation, and they should be incorporated into the operating instructions. Operators and maintenance personnel should be informed about the purpose of monitoring and the impact on fluid life and performance. In general, at the maximum recommended operating temperature, the rate of thermal degradation can roughly double for every 10°C of temperature rise. If severe enough, coke may accumulate on the surface of heating coils and elements.

HTF supplier relationship

HTF end-users should rely on the HTF manufacturer to assist in understanding the proper and safe use of the fluids within the specific constraints of their unique system. The key source of fluid-specific knowledge rests with the fluid supplier, so make sure they are part of the team. ■

Ethylene Dichloride Production

By Intratec Solutions

Ethylene dichloride (also known as 1,2-dichloroethane, as well as EDC and DCE) is by far the most widely produced chlorinated hydrocarbon. The vast majority (~95%) of EDC is employed in the manufacture of vinyl chloride monomer (VCM), which is in turn mostly used as the starting material for the plastic polyvinyl chloride (PVC). EDC can also be used as an intermediate in the production of chlorinated solvents, such as trichloroethylene, ethylene amines, vinylidene chloride and trichloroethane.

The process

The following describes a process for EDC production from ethylene and chlorine. Figure 1 presents a simplified flow diagram of the process.

Direct chlorination. In the direct chlorination step, chlorine and ethylene are fed to a high-temperature chlorination (HTC) reactor filled with liquid EDC as the reaction medium. Heat from the highly exothermic reaction is removed by boiling off EDC, and by the circulation of EDC, which is recycled from the product column downstream. Ferric chloride ($FeCl_3$) is used as a catalyst. About 99% of the ethylene and almost 100% of chlorine are converted, with high selectivity, to EDC. Unavoidable side reactions generate polychlorinated compounds as byproducts (mainly 1,1,2-trichloroethane). Among the byproducts, those with boiling points higher than EDC are primarily withdrawn from the bottom of the reactor as a liquid stream. The gaseous effluent from the chlorination unit, containing the EDC product, is routed to the purification steps downstream.

Product column. In this area, the gaseous effluent, rich in EDC, is passed through a heat exchanger, where it generates steam while being partially condensed by boiler feedwater. The EDC-rich stream is then fed to a distillation column, where it is purified by separating residual byproducts. The stream withdrawn from the column overhead is then cooled in a cooling water condenser, yielding a liquid stream composed of EDC 99.5 wt.%, which is pumped to the EDC tank. Non-condensed gases — mainly ethylene, nitrogen, chlorine, HCl and residual water and EDC — are then passed through a second condenser using refrigerant fluid. After this second condensation step, uncondensed gases are routed to an incinerator located outside battery limits. The column bottom product composed of EDC and polychlorinated compounds is recycled to the direct chlorination reactor. Part of this stream is purged to avoid the buildup of impurities.

EDC tank. The EDC product is stored in intermediate tanks before it is directed to storage facilities located outside battery limits.

Production pathways

Ethylene dichloride production routes are primarily based on the chlorination of ethylene: direct chlorination by chlorine or oxychlorination by hydrogen chloride. Figure 2 presents these two different pathways for EDC production.

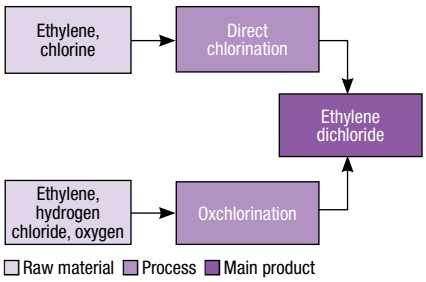


FIGURE 2. There are two main production pathways for EDC

Economic performance

The total operating cost (raw materials, utilities, fixed costs and depreciation costs) estimated to produce EDC was about $510 per ton of EDC in the second quarter of 2014. The analysis was based on a plant constructed in the U.S. with capacity to produce 500,000 metric tons per year of EDC.

This column is based on "Ethylene Dichloride from Ethylene and Chlorine," a report published by Intratec. It can be found at: www.intratec.us/analysis/edc-e11a. ■

Edited by Scott Jenkins

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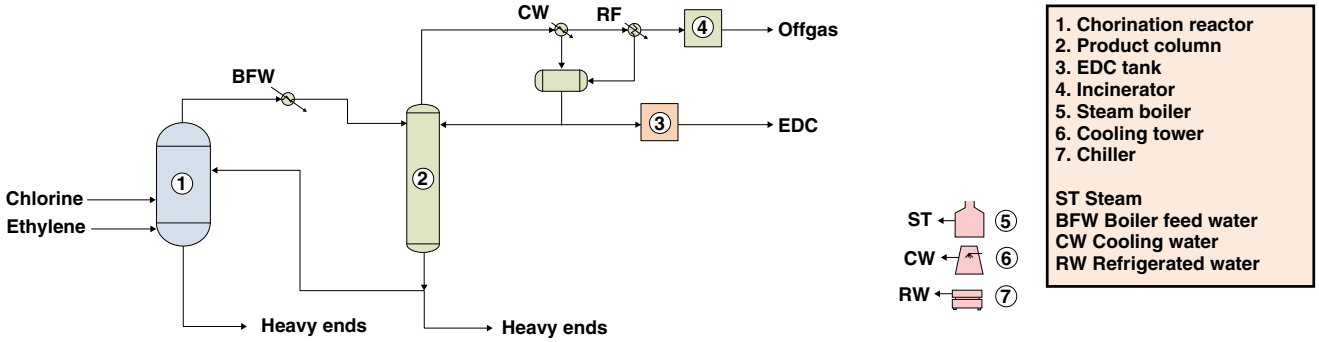

FIGURE 1. The process diagram shown here illustrates the production of ethylene dichloride from ethylene and chlorine

Effective Agitator Operation and Maintenance

Agitators play key roles in chemical processing. Their proper operation and maintenance can improve process reliability, leading to reduced downtime and costs

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IN BRIEF

Agitators, which are relied upon to dependably and cost-effectively meet production goals, are commonly used throughout the chemical process industries (CPI). Despite their prevalence and importance, agitators are rarely the focal point of process hardware. In fact, a properly functioning agitator is usually a case of "out of sight, out of mind." It is when an agitator is not working properly that it garners the most (unwanted) attention. The purpose of this article is to outline best practices for agitator operation and maintenance to ensure reliability and reduce the costs and headaches associated with process downtime.

FIGURE 1. Typical agitator components are shown. On the left is a parallel-shaft drive unit, and the image on the right displays a right-angle drive unit

Agitators share significant characteristics with other rotating equipment, particularly pumps. The most apparent similarity between pumps and agitators is the production of fluid motion via impeller rotation. However, the scope of process objectives to be accomplished by agitators is much broader than that of pumps. While the primary purpose of pumping is to transport material from point A to point B, agitators are used to achieve numerous objectives that include blending miscible liquids, increasing mass transfer rates between immiscible phases, contacting reactants, suspending and dispersing solids in liquids and aiding process control by promoting heat transfer. To meet these objectives, an agitator must be designed, installed, operated and maintained properly.

A key point that should be made at the loutset is that equipment vendors provide detailed instructions via installation, operation and maintenance (IOM) manuals, and these documents should serve as the primary information source to ensure safe, reliable and effective agitator operation. Furthermore, adherence to vendor guidelines is required to avoid invalidating the manufacturer's warranty. Such specific information as provided in IOM manuals will not be presented here; rather, the focus will be on general practices that promote dependable agitator performance.

Agitator components

Figure 1 illustrates the components of a typical agitator. The agitator induces liquid motion through the rotation of an impeller system within the liquid. The impeller is mounted on a shaft connected to the agitator drive

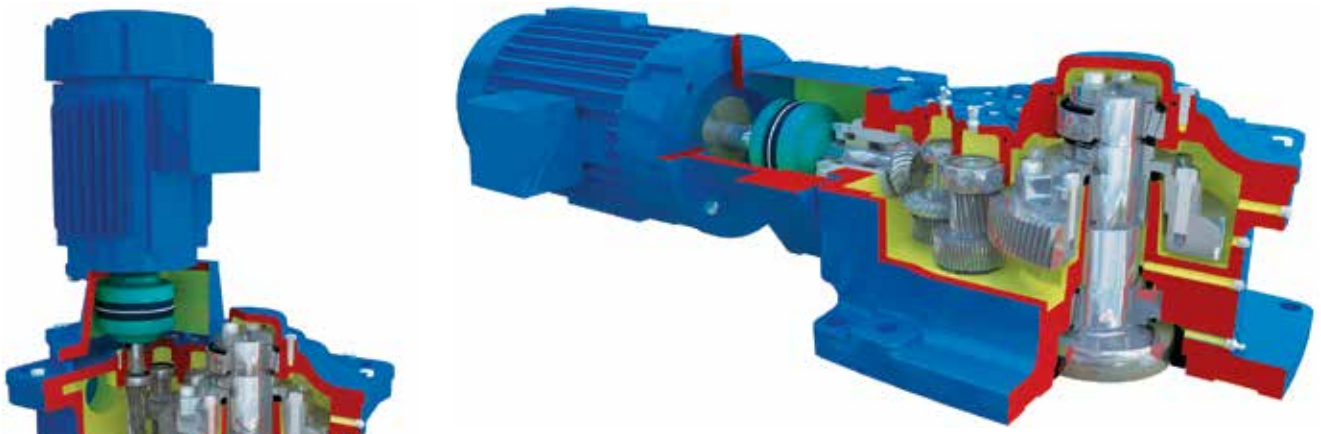

FIGURE 2. These cutaway illustrations show the internal workings of an agitator's gear drive, for both parallel-shaft drives (left) and right-angle drives (right)

that is powered by the prime mover, which is most often an electric motor. The purpose of the agitator drive is to reduce the high motor-output speed to the desired shaft-rotational speed. This speed reduction is usually accomplished by gears, but belts and sheaves are also used.

Figure 2 displays cutaway views of the gear drives shown in Figure 1. The agitator will be mounted on the vessel, beams or an independent structure, and in many cases, a seal is included to contain process material within the vessel. In low-viscosity applications, baffles are employed to eliminate swirl and convert the rotational motion of the impeller into the desired flow pattern throughout the vessel. All of these components must work in concert for an agitator to provide worry-free performance.

Getting off to a good start

Successful agitator operation is rooted in the design process that takes place before an agitator is operational. While smaller agitators may be portable and multipurpose, larger agitators are typically designed to accomplish specific process objectives — for example, blending ingredients to a required uniformity in a specified time, dissolving solids in a stated time or providing a desired rate of interphase mass transfer. The first step of agitator design — specifically, designing to meet process objectives — leads to the specification of a rotational speed and an impeller system that indicates the type, size, number and location of the impellers. Following process design, a mechanical design procedure translates the impeller system and rotational speed selections into hardware that is capable of providing the fluid motion required to meet process objectives while withstanding the mechanical forces that the agitator components will encounter. These forces include the weight of the shaft and impeller system, pressure in the vessel, torque, thrust due to impeller pumping and hydrodynamic forces due to interaction between the blades of the rotating impeller and the material it is moving. These forces, starting at the impeller, are transmitted to the shaft, the agitator bearings and eventually, to the agitator mounting structure. A challenging aspect of agitator mechanical design is that the forces experienced by an agitator are not static; rather, the forces are dynamic and fluctuate with time, particularly the hydrodynamic forces the moving fluid imparts to the impeller system when in turbulent operation.

While the process and mechanical design procedures are not the focus of this article and have been described elsewhere (see Additional Resources box on p. 42), effective communication

TABLE 1. 'RED FLAG' PROCESS DETAILS THAT OFTEN COMPLICATE AGITATOR DESIGN AND OPERATION

Impeller operation at or near liquid surface
Liquid surface passing through the impeller during vessel filling or draining
Operation near or above the critical speed, also termed first natural frequency
Non-standard baffling; unbaffled and under-baffled systems are subject to swirling flow
Off-center or angled mounting
Cone-bottom vessel
Vessel internals (for instance, heating or cooling coils)
Vessel containing multiple agitators with interacting flows
Significant continuous flow (particularly if opposing agitator pumping or impinging on an impeller)
Variable process conditions (such as gas flowrate, solids loading or liquid viscosity)
Startup in settled solids
Complex fluid rheology (including non-Newtonian liquids or fluids with yield stress) or changing rheology
Use of an agitator in an alternative application for which it was not designed

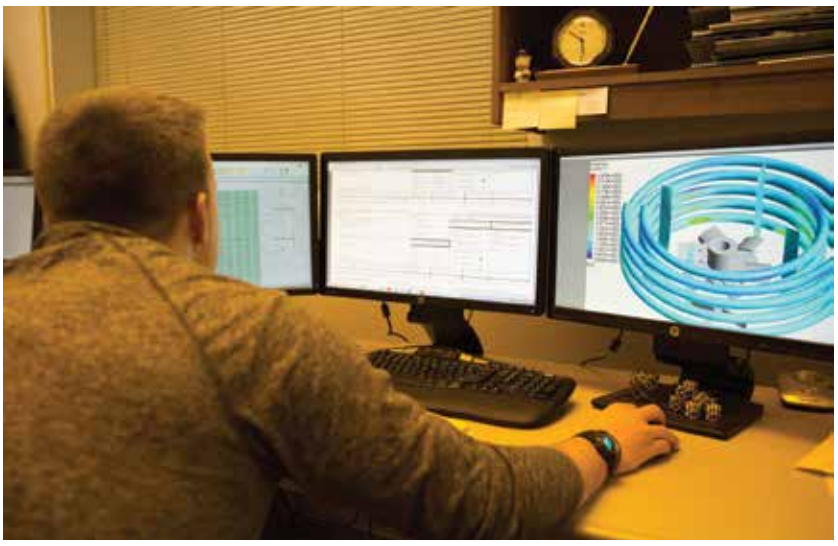

FIGURE 3. Computational fluid dynamics (CFD) analysis can be used to determine the effects of internals, such as heat-exchanger coils, on agitator performance

is important at this stage to avoid operational problems that can plague an installed agitator. This communication can be complicated by the number of players involved, including: the user; the agitator vendor (who likely acquires the motor and seal from secondary vendors); the vessel vendor; and perhaps an engineering and construction firm. For the agitator vendor to design and deliver an agitator that will provide optimal, trouble-free operation, it is imperative that they are provided with key information that will impact the design procedure, particularly process details that may influence the mechanical design. Providing accurate information can be challenging for the user due to the competing forces of the desire to be quick to market with a product and the long lead times required to design and construct a plant, which can lead to process changes occurring after equipment procurement has been initiated.

Although it is impossible to list all situations that complicate agitator design, Table 1 identifies some of the more common scenarios that can lead to agitator operation problems if not properly taken into account. For example, heating or cooling coils are commonly used in agitated vessels, and their presence can strongly impact agitator performance. When significant heat-transfer area is required and numerous closely spaced tubes are used, the flow pattern produced by the agitator can be altered. The fluid velocities between the tubes are reduced, diminishing the effectiveness of both the agitator and the heat-transfer equipment. Additionally, when internals are in close proximity to an impeller or adversely affect the flow pattern generated by the impeller, the hydrodynamic forces experienced by the agitator can be increased dramatically. During the design stage, it is crucial that the agitator vendor prompts the user to provide the right information and that the user understands that seemingly minor process changes can have a significant impact on agitator design and performance (Figure 3).

Getting up and running

Once an agitator has been designed, built and delivered, it must be installed

FIGURE 4. Correct agitator installation is critical for reliable operation

FIGURE 5. Alignment and balancing are required to minimize the adverse effects of hydraulic forces on agitator components

TABLE 2. KEYS TO SUCCESSFUL AGITATOR INSTALLATION
Supports and structure are designed to withstand agitator loads (reaction torque, bending moment and weight)
Shaft straightness within manufacturer's recommended tolerances as verified by runout measurement
Employ laser alignment if a steady bearing is used
Correct impeller balancing
Proper coupling connections (alignment and specified torque)
Bolts torqued to manufacturer's standards; use of locking devices to ensure fastener integrity
Proper motor alignment
Verify appropriate operation of electrical system, particularly tuning of variable-frequency drive (if used)

TABLE 3. ROUTINE AGITATOR MAINTENANCE ACTIVITIES
Regular oil changes
Regularly grease lubrication points of motor and agitator
Check bolt torque of both rotating components (impellers, shaft and seals) and stationary components (pedestal, motor bracket and mounting flange)*
Check shaft runout (typically 0.005 in./ft of shafting is acceptable such that an agitator with a 30-ft shaft would have an allowable runout of 0.15 in. at the bottom of the shaft)*
Visual check of wetted parts (verify that no product buildup or damage has occurred)
Visual check of stuffing box or seal (adjust as necessary to keep proper seal)

** indicates activities likely to be performed during regular outages or shutdowns*

TABLE 4. COMMON CAUSES OF AGITATOR EXCESSIVE TEMPERATURE, NOISE AND VIBRATION
Bearings require replacement
Oil change needed
Inadequate mounting structure
Insufficient bolt torque
Misaligned or bent shaft
Imbalanced impeller, perhaps due to loss of a blade or uneven blade wear
Solids buildup on impeller
Steady bearing wear (if used)
Anti-lock or anti-seize lubricant on tapered couplings
Operation near the critical speed
Impeller operation at or near liquid surface, liquid surface passing through impeller
Flooded gas-dispersion impeller (impeller not dispersing incoming gas)

FIGURE 6. Routine maintenance activities, such as oil changes, prolong agitator life

and commissioned. Efforts made to ensure proper installation can pay dividends, since this is one of the most common failure points (Figure 4). As in the design process, communication between the user, agitator vendor, tank fabricator and, for larger projects, engineering firm, is crucial to proper installation. Subsequently, proper installation is crucial to an agitator's ability to provide extended, reliable service. Communication may be complicated at this point, because the individuals responsible for agitator installation are likely to differ from those who are responsible for design. So not only is communication among the various parties critical, but good communication within each individual organization must be emphasized as well.

As with all rotating equipment, proper alignment and balancing during installation sets the stage for operating success (Figure 5). For top-entering agitators with long, cantilevered shafts supporting rotating impellers that are subjected to significant hydrodynamic forces, alignment and labanacing are particularly important. Further, since the power draw of an impeller is strongly dependent on its diameter — being proportional to diameter raised to the fifth power in turbulent operation — it is imperative that the vendor provides uniform impeller blade lengths and that the blades are correctly attached to the impeller hub. Small differences in blade length, whether due to improper manufacturing or installation, will translate into significant differences in power draw and the resulting forces on the impeller blades. Imbalanced blade forces lead to shaft deflection and forces that are transmitted throughout the agitator and its mounting structure. Table 2 provides guidelines to facilitate the agitator installation process.

Keeping a good thing going

The lifetimes of most agitators are measured in years or decades, requiring maintenance and repair to perform up to expectations and meet process objectives over this timespan (Figure 6). Most routine maintenance activities, such as those listed in Table 3, are relatively obvious and are described in detail in the equipment manufacturer's IOM manuals. The frequency of these actions depends on the use of the agitator,

FIGURE 7. Agitators should be inspected for solids buildup that can cause noise, vibration and equipment damage. Note that in this image, the shaft is horizontal and the lower impeller to the right is almost completely obscured by solids

as well as its physical environment. For example, does the agitator operate continuously or intermittently; is it located outdoors or indoors; is it subject to heat, cold or frequent rain?

Agitators should also be routinely inspected for operating temperature, noise and vibration. If any of these parameters are outside the normal recommended range, catching the anomaly early will prevent additional damage to the agitator and often will result in a less costly repair. Finding the problem source may be tricky, but can often be accomplished by the maintenance crew. In particularly challenging situations, the manufacturer will provide a trained field service technician to offer assistance or ask the user to return the agitator to the manufacturer or a nearby service center for evaluation. Table 4 lists some common causes of agitator

ADDITIONAL RESOURCES

The importance of reliable equipment operation is a given in the CPI as evidenced by the many publications focused on this topic. Compilations available through *Chemical Engineering* [*1*] include a number of articles pertinent to agitator operation and maintenance. With a focus on centrifugal pumps but applicable to all rotating equipment, Chatterjee [*2*] identified the importance of communication between end users, project teams and equipment vendors to ensure low cost, reliable and effective operation of installed equipment. To enhance communication and teamwork, Chatterjee outlined a checklist approach that addresses routine maintenance, safety and environment, troubleshooting and repair and replacement considerations. Almasi [*3*] discussed proactive monitoring of key parameters of rotating equipment, such as vibration and noise levels, to detect root causes and correct problems early to avoid major upsets and downtime. Although the emphasis is on compressors and gas and steam turbines, the approach is applicable to agitators as well.

While agitation has been applied industrially for a very long time, open documentation of this practice has been common only during the past 50 to 60 years. A landmark publication was the 12-part Liquid Agitation series [*4*] published in the mid-1970s. This compilation covered all aspects of industrial agitation, starting with fundamentals, such as dimensional analysis of the Navier-Stokes equations; moving through process design to achieve desired performance in blending, solid-liquid and gas-liquid operations; on to mechanical design to ensure agitator integrity; economic analysis; scaleup procedures; and application guidelines for specific common agitator applications. The seventh and eighth installments [*5*, *6*] of this series focused on hardware and mechanical considerations pertinent to agitator operation and maintenance. A second article series, Advanced Liquid Agitation [*7*], concentrated on improvements in impeller technology, computerized selection procedures and advanced experimental and computational methods that can be used to optimize agitator design and performance. A companion article [*8*] to this updated series discussed advanced methods of mechanical design including consideration of mechanical seals, fastener locking techniques, material of construction, and structural stiffness that are critical to trouble-free agitator operation.

Professional societies, most notably the American Institute of Chemical Engineers (AIChE; New York, N.Y.; www.aiche.org), have played a key role in disseminating best agitation practices through conferences and publications. AIChE's Equipment Testing Procedures Committee published a compendium of agitator testing information [*9*] that encompasses both process and mechanical considerations, such as shaft runout, gear tooth patterns, seals, noise and vibration, torque and power draw. Undoubtedly, the most comprehensive source of agitation information is the Handbook of Industrial Mixing [*10*] that was brought to fruition through the efforts of AIChE's North American Mixing Forum (NAMF). With authors representing academia, industry, and equipment vendors, this work includes fundamentals (including turbulence and residence time distribution), experimental and measurement techniques, computational fluid mixing, specialized mixing devices (such as rotor-stator devices), typical agitator applications (miscible liquids, immiscible liquids, gas-liquid, solid-liquid or chemical reactions) and agitation in specific industries (including polymers, pharmaceuticals, petroleum and pulp and paper). The two chapters dealing with mechanical design [*11*] and the equipment vendor's role [*12*] are particularly pertinent to the present focus on agitator operation. The recently published Advances in Industrial Mixing [*13*] provides updates on some topic areas in the original Handbook of Industrial Mixing and completely new subject areas (for instance, micromixers, mixing in the food industry and mixing safety), as well as a chapter on commissioning mixing equipment [*14*] that outlines procedures to be used during installation to promote a smooth-running agitator. ❑

operational problems. Note that a number of these causes, such as shaft misalignment and insufficient bolt torque, may be rooted in the installation procedure, reinforcing the benefits of making the effort to get this important preceding step right. Solids buildup is another major cause for concern, as seen in Figure 7.

FIGURE 8. Trained field service technicians can facilitate the installation process and assist in the identification and correction of operational problems

For agitators equipped with a seal or steady bearing, monitoring these can be an effective indicator of the overall status of the agitator. Like tires on a car, agitator seals and steady bearings will show wear. Uniform wear is expected, but non-uniform wear is likely a sign of misalignment or some other problem. Changes or fluctuations in the temperature, pressure, or level of seal barrier fluid are usually early indicators of problems, and when detected, should be followed up with a thorough inspection of the agitator to identify and correct the root cause of the behavior.

When the going gets tough

When an agitator or other process hardware does not perform up to design expectations, prompt identification and correction of the cause is imperative, particularly when process downtime occurs. This is the role of the vendor's field-service group (Figure 8). Rapid

resolution can often be aided by providing detailed operating information to the vendor. Of particular importance are records of temperature, pressure, power draw and vibration. Additionally, changes in the process or procedures should be communicated, as they may be related to the problem. Have flowrates, process conditions or fluid properties such as viscosity changed? Is the agitator being turned off and on rather than being operated continuously? What has changed that might be responsible for the reduction in agitator performance?

Having spares on the shelf

Agitators typically are a significant piece of equipment in a chemical plant. When purchasing an agitator, it is important to evaluate the impact the agitator has on maintaining process operability. If the process cannot function, or functions at significantly lower efficacy without the agitator, the manufacturer should be contacted to determine how long would be required to obtain a replacement. If the delivery time is too long or the risk too high, it is suggested that a spare agitator or key spare parts be kept on the shelf. Having a spare could save your process from significant downtime, but this peace of mind comes at a price, so a cost-benefit analysis should be used to determine whether a replacement agitator should be kept on hand. Having a spare agitator can pay dividends, but proper storage is required to ensure the spare will be ready when needed. Otherwise, the additional investment may be wasted on a non-functional replacement. Points to consider when storing an agitator are discussed in the following section.

In an effort to help operators keep their agitators and processes up and running, equipment vendors offer reliability planning services to identify key spare agitator components that the user should keep on hand. Agitators are a combination of off-the-shelf and custom components. For instance, the shafts of larger agitators are customized to provide the appropriate overall length and impeller mounting locations for a particular installation. Similarly, impellers are sized to satisfy specific process objectives. Conversely, for many agitators, a standard motor will be suitable. Reliability planning distinguishes between standard components for which the vendor can quickly provide replacements and unique components for which spares should be stocked. Various factors, such as materials of construction, contribute to making an agitator component unique, and the equipment vendor will work with the user to develop a sound spare-parts stocking strategy.

Finding renewed purpose

Given the potentially long lifetime of a well-maintained agitator, it may outlast its original function and be

FIGURE 9. Careful record keeping and parts inventory are recommended during agitator storage (See Table 5)

repurposed in a new application. The preceding discussion tacitly focused on new agitators, but the considerations are much the same when an existing agitator is used for a new purpose. However, there are a few additional issues that should be considered in this instance. Good record keeping is of particular importance in this regard so the agitator can be properly evaluated for both its process and mechanical suitability for the new application. Once the pertinent parameters of the new process are known, contact the agitator manufacturer or their local representative and ask if the agitator should be used in the new application. Rarely will the agitator be optimized for the new circumstances, but with an easy change of rotational speed or impeller system (type, diameter, location or number of impellers), the agitator may be successfully used in the new process. If modifications are made, detailed record keeping again becomes important for continued trouble-free operation. Knowledge of changes to the agitator should be incorporated into the maintenance strategy and need to be known if troubleshooting poor performance becomes necessary.

If an agitator is decommissioned from one application and then repurposed in a different one, storage is most likely required (Figure 9). As mentioned in the preceding section, spare agitators and parts must also be stored, and even new agitators require short-term storage if not installed upon receipt. Proper storage is required for an agitator to perform up to expectations when recommissioned. Table 5 lists some key considerations for agitator storage.

From design to installation to provision and storage of spares, many considerations are critical for ensuring agitators reach their full performance potential. Reliable and effective agitator operation starts during the design process, before the agitator even exists, and is followed by proper installation, commissioning and maintenance throughout the agitator's lifetime that

TABLE 5. AGITATOR STORAGE CONSIDERATIONS
Environment affects storage — for instance, dryness, temperature, controlled or variable conditions, indoor or outdoor locations (note that outdoor storage is not recommended)
Motor and gear drive shafts must be rotated on a regular basis
Fill gearboxes with oil for longterm storage and vapor-phase rust inhibitor for moderate storage periods
Keep parts out of harm's way to avoid damage; most notably, do not take shafts out of storage crates
Store everything together and inventory all parts so items are not lost prior to installation

may include reincarnations in a number of applications. By working cooperatively with an experienced equipment vendor and applying the best practices described here, your agitator can provide extended and dependable service. ■

Edited by Mary Page Bailey

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PVDF: A Fluoropolymer for Chemical Challenges

When it comes to selecting materials of construction, keep in mind the favorable properties of fluoropolymers for corrosive service

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IN BRIEF

Since its commercialization in the mid-1960s, polyvinylidene fluoride (PVDF) has been used across a variety of chemical process industries (CPI) sectors due to its versatility and broad attributes. With flagship applications in architectural coatings and the CPI, the breadth of industries where PVDF is utilized today is expansive. PVDF components (Figures 1 and 2) are utilized and installed where engineers are looking to maximize longevity and reliability of process parts in many CPI sectors, including semiconductor, pharmaceutical, food and beverage, petrochemical, wire and cable, and general chemicals.

FIGURE 1. A variety of fluoropolymer components are shown here

PVDF and the fluoropolymer family

PVDF is a high-performance plastic that falls into the family of materials called fluoropolymers. Known for robust chemical resistance, fluoropolymers are often utilized in areas where high-temperature corrosion barriers are crucial. In addition to being chemically resistant and non-rusting, this family of polymers is also considered to have high purity, non-stick surfaces, good flame and smoke resistance, excellent weathering and ultraviolet (UV) stability.

Fluoropolymers have carbon and fluorine as the main components of their chemical backbone. Small changes in percent fluorination or addition of other elements may change the performance properties. Fluoropolymers are divided into two main categories: perfluorinated and partially fluorinated [*1*]. The partially fluorinated polymers contain hydrogen or other elements, while the perfluorinated (fully fluorinated) polymers are derivatives or copolymers of the tetrafluoroethylene (C_2F_4) monomer. Commonly used commercial fluoropolymers include polytetrafluoroethylene (PTFE), perfluoroalkoxy polymer (PFA), fluorinated ethylene propylene (FEP), polyvinylidene fluoride (PVDF), ethylene tetrafluoroethylene (ETFE), and ethylene chlorotrifluoroethylene (ECTFE).

PVDF is a partially fluorinated polymer consisting of repeated units of the vinylidene fluoride (VF2) monomer [($C_2H_2F_2$)]. Standard PVDF homopolymer is 59.4% fluorinated and PVDF copolymers (described in later sections) can reach up to 65% fluorination. Generally, the higher the fluorine content, the higher the chemical resistance, as the carbon-fluorine bond is one of the strongest known in chemistry. PVDF homopolymers can tolerate chemistries from a pH of less than 1 up to 12 and PVDF copolymers can extend that range from much less than 1 up to 13.5.

While PTFE, with its high melting point of 325°C, is well known as a liner for high temperature applications, PVDF homopolymer has a melt point between 165 and 172°C and

FIGURE 2. These fluoropolymer tower packings are used in distillation columns

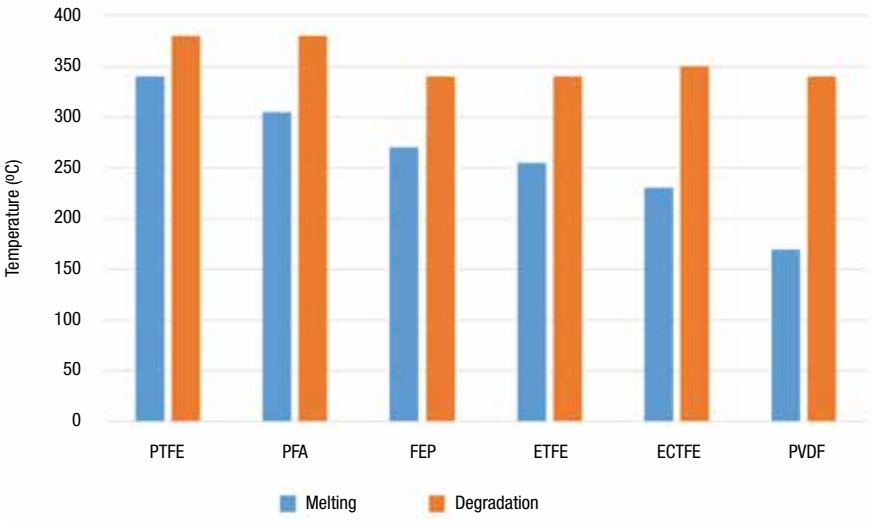

FIGURE 3. The processing temperature window for several fluoropolymers is shown here

maintains a Underwriters Laboratories (UL) relative thermal index (RTI) rating of 150°C [*2*]. Table 1 shows the heat deflection temperature of fluoropolymers with PVDF holding mechanical integrity under pressure up to its usage certification temperature.

Aside from PTFE, which is most often processed by sintering, most other commercial fluoropolymers are melt processable, and require high heat to process in a molten state [*4*]. Equipment used to make most fluoropolymer components must be therefore equipped to handle the associated thermal stresses. Special considerations related to temperature requirements must be taken into account when processing most fluoropolymers.

Unlike its fluoropolymer counterparts, PVDF is the most benign to process. PVDF has the widest gap between its melt temperature and its degradation temperature, as shown in Figure 3. In fact, PVDF does not require special equipment and can be processed on standard equipment used to process polyolefins, such as polyethylene (PE) and polypropylene (PP).

Copolymers flexural properties

While PVDF is the strongest of the fluoropolymers up to 140°C, PVDF copolymers can bring added degrees of flexibility. Copolymerization is a true chemical reaction. It does not involve additives or stabilizers that can leach out over time. Some of most common comonomers are hexafluoropropylene (HFP), tetrafluoroethylene (TFE), and chlorotrifluoroethylene (CTFE). HFP is a fully fluorinated monomer that disrupts the crystallinity of PVDF, resulting in added ductility and increased elongation [*5*]. Varying amounts of HFP can be reacted with VF2 to yield broad ranges of flexibility. Table 2

FIGURE 4. Wire and cable components are commonly made of fluoropolymers

gives an example of the range of flexural moduli of PVDF, both homopolymer and copolymer, compared to other fluoropolymers.

Variations in material flexibility result in a wider range of components available in PVDF materials. While PVDF homopolymer has a long legacy of use in piping, valves, pumps and other applications that require high mechanical rigidity, the PVDF copolymer range has a variety of melt-processed components, such as wire and cable jacketing (Figure 4), tubing, hoses and gaskets, to name a few.

PVDF components

As previously described, the properties of PVDF make it useful across a variety of applications. The following are just a few highlighted components where PVDF materials are specified to bring long-lasting solutions.

Piping systems. PVDF piping systems (Figure 5) have a UL RTI rating of 150°C (302°F) and are available in various forms: solid piping, lined metal piping and fiberglass-reinforced dual laminate piping. Unlike metals, PVDF is non-rusting and lightweight, making installation easier.

PVDF piping systems can be joined by various welding techniques. Socket fusion is a recommended method in the CPI, as the strong weld creates a lap joint that can resist harsh chemistries, such as hydrochloric, sulfuric, and nitric acids. Butt fusion, one of the easiest types of joining methods, is a choice in areas where the chemistries are more benign. Beadless and smooth inner bore systems leave no welding bump, which make them ideal methods for the pharmaceutical and semiconductor industries. Both of these industries need a smooth surface to minimize bacterial hang-ups and ensure the highest levels of purity. Mechanically joined and threaded systems are utilized for applications where systems are taken apart to be cleaned. PVDF piping can withstand sterilization with saturated steam at temperatures [*6*] up to 150°C depending on the joining method and design.

FIGURE 5. PVDF piping systems come in a various forms

Flexible tubing. Flame and smoke additives can be added to PVDF resins to meet the stringent standards of ASTM International E84 (UL723) 25/50 [*7*] and at least one formulation of PVDF holds a 0/5 ASTM E84 rating using no additives at all, and is compliant with U.S. Food and Drug Administration (FDA) and National Sanitation Foundation (NSF) standards [*8*]. Piping systems for waste drainage applications along with wire and cables made with PVDF are widely specified in the plenum areas of buildings. Electrofusion is a specialized pipe-joining technique for that industry, where built-in electric heating elements are used to weld the joint together, thereby minimizing human error in fabrication.

While PVDF piping systems are used in areas where high mechanical rigidity is crucial, flexible tubing options are also available that take advantage of PVDF copolymer technology (Figure 7). With flexural moduli down to 10,000 psi, tubing is important in applications like beverage and fuel lines that can be utilized in many market segments. The beverage industry appreciates minimal cross-contamination of taste, making PVDF tubing a long-lasting choice. Several PVDF copolymers are FDA compliant per Title 21 CFR 177.2600 and are listed to NSF 51 for food contact. For fuel applications, the barrier properties of PVDF are used for low permeation of hydrocarbons in flexible fuel pipes, such as applications compliant with UL 971 Nonmetallic Underground Piping for Flammable Liquids. Fluid handling systems with PVDF can also be created in multilayer constructions, where a tie layer is used to bind the PVDF to another material, such as polyurethane or polyethylene. With PVDF as the fluid contact layer on the inside and an engineering polymer material on the outside, the cost of the multilayer construction may be more economical for some applications.

FIGURE 6. Electrofusion is one joining method of PVDF systems

FIGURE 7. This flexible tubing is made from PVDF copolymers

FIGURE 8. PVDF fittings are one example of injection-molded pieces

TABLE 1. DEFLECTION TEMPERATURE OF FLUOROPOLYMERS* [3]			
Material	**Melt point, °F**	**Def. temp. at 66 psi,°F**	**At 264 psi,°F**
PTFE	620	250	132
PFA	590	164	118
FEP	554	158	124
ETFE	518	220	165
ECTFE	464	240	170
PVDF	352	298	235

* ASTM D648

Injection molded components. Piping systems and flexible tubing are usually created via profile extrusion but injection molding is another method to create components in specialized shapes and dimensions. From pumps, nozzles, and valves, PVDF components can be mass injection molded (Figure 8). Recently, PVDF components are being molded for conveyor belting for food-processing facilities.

Traditional materials used in plastic modular belting have faced scrutiny recently due to plastic bits contaminating food [9]. With PVDF, the higher mechanical and abrasion resistance combined with outstanding chemical resistance have proven to be a longer-lasting solution. Both rigid and copolymer grades of PVDF can be molded into a variety of parts. Unmodified PVDF resins have a shrink rate of about 2–3% depending on part geometry and thickness. Engineers must take these values into account when designing molds for part production.

Recently, innovations in modifying PVDF resins have produced products that have reduced shrink values. By adding a carbon filler to the PVDF resin, shrink rates similar to polypropylene or polyethylene are obtained. Thus, PVDF can be substituted into those molds with minimal process adjustments. Additionally, glass-reinforced PVDF resins (Figure 9) strengthen PVDF to yield a flexural modulus (ASTM D790) over 1 million psi, similar to that of PEEK (polyether ether ketone) for a fraction of the cost. This glass-reinforced PVDF resin has a very low shrink rate of less than 1%.

Stock shapes. Rods and sheets are produced with PVDF resins for making stock shapes (Figure 10). These components can be utilized by component fabricators to create specialized parts. Rods and sheets can be cut, formed and machined into components that have tight tolerances. Additionally, stock shapes make PVDF components available to original equipment manufacturers (OEMs) that need the material properties of PVDF without having to invest in injection molding equipment.

PVDF sheets are commonly used in the tank industry. Tanks can be fabricated using a variety of techniques from solid PVDF, to linings on metal or fiberglass-reinforced tanks. Facilities that have corroding or rusting metal tanks may find PVDF sheet linings a viable solution to retrofit in the existing structure.■

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FIGURE 9. Glass-reinforced PVDF resin can be used for bolts

FIGURE 10. PVDF rods can be machined into specialized components

TABLE 2. FLEXURAL PROPERTIES OF PLASTICS*	
Material	Flex modulus, psi
PVDF homopolymer 740	300,000
ECTFE	240,000
PVDF copolymer 2850	170,000
ETFE	170,000
PVDF copolymer 3120	110,000
PVDF copolymer 2800	100,000
FEP	85,000
PFA	85,000
PTFE	72,000
PVDF copolymer 2750	60,000
PVDF copolymer 2500	35,000
PVDF copolymer Ultraflex	10,000

*ASTM D790 at 73°F

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Integrity of Aging Assets: Using Corrosion Data to Stave Off Extinction

Petroleum refineries built in the 1960s and 1970s have trouble dealing with the corrosive effects of modern feedstocks. Continuous monitoring of corrosion can prevent process equipment failures

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IN BRIEF

Aging assets that are past their original design life are becoming an increasingly stark problem for the global oil-and-gas industry. In fact, mature assets currently account for more than 70% of global oil-and-gas production.

When the oil and gas fields these assets were designed to use as feedstock were first discovered, enhanced oil recovery techniques, such as thermal recovery, hydraulic fracturing, and gas- or chemical-injection technologies had not yet been employed. With the evolution of technology, operators have been able to increase the volumes of recoverable reserves from around 20 to up to 70%. However, oil and gas produced using these modern extraction methods often present corrosion and other problems.

Many operators today are dealing with mature assets installed in the 1960s and 1970s (Figure 1) with an original design life of around 20 years. Having now been in operation for more than double that time, they're at the highest risk point of their lifecycle.

When faced with this scenario, operators need a strong defense to maintain safe, economic production. This is especially true when facing one of aging assets' greatest threats: corrosion.

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FIGURE 1. Aging refineries are now dealing with highly corrosive feedstocks

Corrosion in the oil-and-gas industry is caused by contaminants in produced hydrocarbons that, over time, lead to deterioration of pipe and vessel walls. And it's a growing problem. Experts at NACE International (Houston; www.nace.org), the global corrosion authority, put the total annual cost of corrosion in the oil-and-gas industry at $1.372 billion. Loss of equipment integrity can result in unplanned downtime and costly repairs, or in the worst case, an incident posing major risk to personnel, the environment and stakeholder value.

Aging assets

When building new greenfield assets, corrosion is a problem that can be addressed from the beginning. But when operating brownfield assets, it's a problem that needs to be addressed after the fact in an operating facility. Operators are being faced with a situ-

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FIGURE 2. High TAN crudes cause naphthenic acid corrosion

ation where the asset is at its weakest, while the threat of corrosion is at its highest. Corrosion is thus adding another layer of complexity to assessing future asset strategies and their economic feasibility.

This presents petroleum-refinery operators with a pressing economic decision: do they decommission the asset at a substantial cost and search for ways to replace its production, continue to produce at a potential profit with the associated risk, or find a way to continue operation in a cost-effective and safe manner?

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FIGURE 3. Many areas in refineries are susceptible to corrosion, but corrosion monitors can detect problems

Since capital investment budgets are always limited and risk-reduction is paramount, closely monitoring for signs of poor asset integrity and proactively addressing problems is often the preferred option.

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FIGURE 4. Corrosion in crude overhead

Changing resources

Aging petroleum refineries were originally designed to handle a certain type of oil, such as "sweet crude." The changing nature of oil being supplied for processing magnifies corrosion problems in aging refineries. The availability of light tight oils (LTOs) is driving U.S. refiners to take advantage of the significantly higher margins that can be achieved from processing this feedstock.

The production of LTOs relies on the use of fracking fluids, a combination of chemicals used to stimulate oil to flow from the field. In many instances, these chemicals can end up in the crude oil feedstock to the refinery. In addition, the transportation of LTOs by railcar requires the addition of H_2S scavenger chemicals that can introduce other corrosion-related problems. These amine-based compounds can deposit as salts in the top section of crude towers, top pumparound and draw trays — with the resulting possibility of more corrosion.

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FIGURE 5. Ultrasonic corrosion sensors can be permanently installed on a pipe line

Canadian oil sands often have a high total acid number (TAN). Many of the world's existing refineries were designed to process crudes with a TAN of 0.3 mg KOH/g or less, but some oil sands have a TAN of 1 mg KOH/g or more. These crudes are often discounted by several dollars per barrel ($/bbl) against the normal marker crudes, like Brent or West Texas Intermediate (WTI). A discount of just $0.50/bbl from the standard feedstock slate for an opportunity crude could raise the profitability of a typical 200,000-bbl/d refinery by $35 million/yr.

High TAN crudes bring naphthenic acid corrosion, a particularly aggressive and often localized form of corrosion, characterized by the "orange peel" effect (Figure 2). While this issue is primarily centered on crude and vacuum distillation units, gasoil and residue products fed to downstream conversion and hydroprocessing units can also exhibit TAN levels that cause problems in feed section equipment, especially when fabricated from carbon steel.

In addition to LTOs and oil sands, many operators are exploring a wider range of feedstocks and are testing new crudes. This creates the possibility of other corrosive species such as acids, which are usually residues from chemicals used for well stimulation in the upstream oil production process, being introduced into the crude unit.

Refiners have two principal mitigation strategies for acid corrosion: they can upgrade the metallurgy of many or all susceptible areas, often to high grade, expensive alloys, such as hastelloy, monel or titanium; or they can use chemical treatment. In both cases, these strategies should be combined with tighter corrosion monitoring at critical locations to verify inhibitor distribution and effectiveness, and/or the effectiveness of the metallurgy upgrade.

Assets at risk

Aging assets that are prone to corrosion include sour water strippers, crude overheads, amine units and many other operating units (Figure 3).

Sour-water-stripper tower corrosion and fouling from corrosion byproducts, such as iron sulfide, are common operational problems compromising asset integrity. Tower and crude overhead sections are exposed to high levels of H_2S and NH_3 and can experience high rates of ammonium bisulfide corrosion. Corrosion risks can be compounded by high levels of cyanides from upstream units that concentrate in the overheads.

Sour crude processing often results in excessive crude nitrogen content, which is a precursor to the production of cyanides, such as HCN. Cyanides can create corrosion issues in the sour-water system. Produced in the downstream conversion units, such as the fluid catalytic

cracker (FCC) or delayed coker, cyanide compounds concentrate in the water phase of the main fractionator overhead. Free cyanides can be deposited in the wet gas stream, causing hydrogen blistering. Cyanides can destabilize any passivation (iron sulfide) layer, causing it to flake off as free iron sulfide, resulting in plugging and fouling downstream (Figure 4).

Amine systems are subject to corrosion by both carbon dioxide and hydrogen sulfide in the vapor phase, the amine solution, and the regenerator reflux, as well as producing amine degradation products in the amine solution. In refineries specifically, amine systems suffer from corrosion by several components not generally found in natural and synthesis gases such as ammonia, hydrogen cyanide and organic acids — some of which will accumulate at various points around the refinery amine system.

Most of the time, the amine absorption and regeneration system operates satisfactorily, and needs little attention and minimal focus from plant operators and engineers. But in the petrpleum refining industry, increasing severity of operation of hydrotreating units driven by ever-lower sulfur specifications for finished gasoline, jet fuel and diesel has increased the pressure on the amine absorption and regeneration system, and the quantity of H_2S has increased as a result. In some cases, the original facilities are being operated at significantly higher processing rates and amine H_2S loading than the original design.

Many refineries and oil terminals are located beside major stretches of water, either sea or river, to provide an easy and cost-effective transportation route via jetties for crude oil and feedstock imports and finished-product exports. Jetties can often be several hundred feet long with multiple berths, and must handle many different products simultaneously.

As a result, multiple oil-product lines are run from shore, suspended below the jetty. In most instances, it wasn't cost effective to construct these jetty pipelines from stainless or alloy steel; instead, carbon steel was used to build the pipelines decades ago.

The use of carbon steel, however, opens up the risk of internal corrosion, particularly with higher-sulfur-content oils (like fuel oils) and fuels containing potentially corrosive additives. The presence and buildup of water allows the accumulation of bacteria that cause microbial-induced corrosion. This issue is especially likely in jetty lines, since they have intermittent or slow flowrates, allowing water to settle in low points.

If undetected, a hydrocarbon leak resulting from corrosion in a jetty line will go straight into the water, interrupt jetty operations while the leak is sealed, and necessitate complex oil-spill response procedures to clean up the water.

In addition to the obvious safety and operational risks, industry regulations are also in place to protect personnel, the environment and equipment from piping leaks. Operators are expected to demonstrate that operational risk from corrosion is as low as reasonably practicable. How can operators of aging assets ensure they are meeting this requirement?

Seeking solutions

The solution is having access to accurate, realtime information about the impact that contaminants are having on the pipe wall thickness of aging assets.

Traditional manual inspection techniques can be used to measure the thickness of the metallurgy at three- to six-month intervals. Aside from the obvious safety risks associated with sending personnel offshore or into a petroleum refinery, measuring pipe-wall thickness at three-month intervals — when a serious event can happen in a matter of days — is a dangerous risk. These traditional methods cannot provide the accuracy, quality and frequency of data necessary to detect potential problems.

Permanently installed, ultrasonic, wireless wall-thickness-monitoring sensors (Figure 5) are ideal for corrosion monitoring because they provide the data required to make proper decisions on a continuous basis.

The installation cost of ultrasonic sensors is low due to their non-intrusive measurement method, allowing them to be mounted almost anywhere. Wireless data retrieval enables cable-free installation, further reducing installation cost and removing any ongoing operating costs. The sensor power packs are designed to last until the next plant turnaround (nine years is typically achievable), so no maintenance is required between turnarounds. This simplicity of installation makes ultrasonic sensors ideal for use in remote locations only accessible during turnarounds.

Once installed, these sensors measure the thickness of the pipe wall and send data directly to server-based analysis software via a wireless network. With the enhanced insight provided by this realtime data, refinery operators can quickly realize improved safety, reduce operational expenditure and increase production from their aging assets.

For example, one commercial software product analyzes and displays information from dozens or even hundreds of corrosion sensors in a plant or refinery, and informs operators when a problem is discovered.

Giving operators access to this kind of corrosion information enables them to make the right decisions at the right time about when and where critical maintenance should be carried out to support safer and more economic operations.

Installing corrosion sensors, a wireless network and server-based software to process the data may sound like a multi-day project requiring asset shutdown, but realtime and wireless integrity monitoring solutions can be easily installed at strategic locations on the outside of equipment in a matter of hours.

Final remarks

Aging assets are at the weakest point in their lifecycle, but when equipped with information about corrosion problems, operators can spot the dangers posed by corrosion and take preventive action before it becomes a major operational risk. Ultimately, in this economic environment, informed decisions can mean the difference between profit and loss, and between asset survival and extinction. ■

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Get the Most Out of an Owner-Contractor Alliance

This article provides guidance for setting up a robust alliance between plant owners and EPC contractors to minimize risk and maximize synergies during complex, capital-intensive projects

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TechnipFMC

The most meaningful collaboration pathway among plant owners and engineering, procurement and construction (EPC) contractors is to create an alliance. Both plant owners and EPC contractors can mutually benefit from a well-designed alliance, which enables both parties to work closely to refine established operating principles throughout the life of a project, and to collaborate on innovative operating approaches and strategies. This article discusses key elements of such an arrangement — from the development of the initial pillars of the relationship to the need for confidentiality and exclusivity — and provides guidelines that can help all parties in an owner-contractor alliance to maximize the benefits over the long run.

Both parties would benefit when they consider the drivers and pitfalls of traditional partnership practices and test today's newer collaboration models and innovative contracting schemes. When certain questions can be answered — such as why does an owner seek an alliance, and what are its potential pitfalls (perceived or real)? — all stakeholders are able to develop an appropriate alliance agreement that is tailored to meet the site-specific considerations of the project or business endeavor.

While alliances are beneficial for both parties, such arrangements are difficult to create and often are not easy to maintain. The following discussion offers recommendations for how to properly set up and maintain a fruitful alliance deal.

The specific areas to be investigated when dealing with an alliance are as follows (each is discussed in detail below):

- Initial expectations
- Commercial considerations
- Maintenance issues
- Project-execution details
- Coordination responsibilities

TABLE 1. TYPICAL KEY PERFORMANCE INDICATORS (KPIs) THAT SHOULD BE CONSIDERED IN ANY ALLIANCE

Operational performance	
Safety	Behaviors, including input and output measures; building safety into design
Stage cost and schedule	Stage deliverables according to agreed-upon budget
Quality of stage deliverables	Fit of deliverables with business needs and receiver's expectations
Strategic performance	
Business alignment	Management commitment; willingness and ability to adapt to changing business environment
Innovation	External input of fresh ideas from the contractor and industry contacts
Market Intelligence	Market Intelligence on competitors and on the supply-chain/markets
People alignment	Continuity of expertise; integration into team; embracing localization
Working-processes performance	
Knowledge management	Intellectual property (IP) protection; using lessons-learned; capturing lessons learned
Planning	Communication and adherence to detailed plans
Reporting and transparency	Clear communication with full transparency of cost and progress
Fit of processes with owner's needs	Processes are tailored to the alliance and applied consistently

Initial expectations

Define the relationship. The scope and mission of the alliance must be defined. For instance, is the alliance being sought for a specific technology, for a determined project phase, or for a specific geography?

Establish metrics and objectives. Because demonstrable results count in an alliance, both parties must work together to define and agree on the most appropriate metrics to be evaluated throughout the life of the working relationship. In particular, leading and lagging indicators must be established, along with key performance indicators (KPIs) that are most relevant for a specific project or projects. Typically operational, strategic and working processes are considered (Table 1).

Agree on how to handle "gain share" and rewards. Based on the considerations listed above, a "gain share" mechanism must be established to reconcile variation in KPIs (for instance, variation in projected capital costs). Both parties will need to define and determine how to share and balance any financial rewards or penalties that may arise throughout the life of the project.

TYPICAL ALLIANCE GOVERNANCE STRUCTURE

Seek alignment on core values and principles. These include, for instance, considerations related to health, safety and the environment; such so-called "sacred cows" must be identified and agreed upon by both owner and contractor to ensure appropriate alignment with respect to these key issues.

Define confidentiality and intellectual property (IP) requirements. To establish a relevant alliance, clear rules must be established with respect to IP and confidentiality issues, and they must be in line with the agreed-upon exclusivity provisions (see next bullet point).

Set expectations about exclusivity. The mandate in this respect must be clearly defined. Is it linked to technology, to a project phase (for instance, front-end loading), to a particular geography? Is it applicable to the contractor's organization at large or to specific operating centers? Is it relevant to a specific type of project (for instance, greenfield, brownfield, debottlenecking or expansion), or to retrofitting or upgrades of technologies? Is it limited to a specific time duration? These are the types of questions to be asked.

Agree on how to share business information. Clear rules must be defined in this respect to protect all parties. The more that effective sharing takes place thoughout the alliance, the more the contractor will be able to gain insight into the project owner's business practices and objectives, and be able to support the the owner's case more appropriately.

Identify key professionals and their roles and responsibilities. The identification of a core team of professionals on the contractor's side is key to guaranteeing continuous improvement, continuity and success within the alliance.

Agree on the alliance location. While there may not be one single location or geographical place that defines the alliance, it is still helpful to gather all of the contractor's pro-

fessionals associated with the alliance in a single office. This allows the contractor to create a "competence center" for that specific project or arrangement.

Commercial considerations

Define accounting, control (especially for shared expenses) and auditing (for rates structure). These important rules of conduct must be established at the deal inception and then refreshed periodically throughout the life of the alliance.

Establish common investments. If the investments (such as those related to the shared information technology domain) might be of value for the contractor even beyond the boundaries of the specific alliance, a shared funding mechanism should be established.

Establish rates, fee structure and a benchmarking framework for incentives. In many alliances, contracting deals use a framework through which the contractor is paid for what it is asked to do in a reimbursable manner, and not via a lump-sum, fixed-cost framework. This is the approach most alliances select, given its flexibility. The appropriate rate structure must be established (including salary and overhead expenses), and it must have a formal, auditable structure. When the alliance is exclusive and guarantees a certain amount of work for the contractor, the overhead costs will be reduced for the contractor, thus incurring fewer "chase costs" on the contractor's side to develop other work and revenue leads. The fees charged during the project's front-end loading (FEL) phase could be structured by dividing it into a fixed component, plus a variable add-on one that is tied to performance. During project execution, an incentive plan should be defined on a case-by-case basis, which typically creates a cap for both the rewards side, as well as "pain areas." Such incentives are typically benchmarked internally by the owner or via an external consultancy. Special attention should be dedicated to project-to-project incentives, which should also be benchmarked and rewarded through a gain-sharing or equivalent mechanism.

Maintenance issues

Identify core technology. It is important for all parties in any technology-based alliance to figure out whether the working arrangement applies to just the latest technology, or to all prior and future vintages of the technology employed, and whether it takes into consideration pilot-plant testing and transitional work to move the process from the research-and-development (R&D) stage to full-scale commercialization. Any maintenance or upgrade of technology should ideally take place between commercial projects and should look at the project execution side of it. Technology application must be reviewed in terms of its feasibility from a project-execution perspective. In a commercially proactive mode, the contractor should develop this type of effort — for instance, zeroing the fee and being compensated just for its actual costs. Relevant domains where these considerations apply include, for instance IT, reliability modeling, and cost-versus-risk estimating and scheduling tools.

Agree on governance and oversight. The structure must be lean, but effective, and must work both top-down and bottom-up. The alliance must include representatives of all current, active projects, to keep the alliance associated with commercial reality. Alliance managers would be key players, especially at the deal inception, and will need to demonstrate full-time presence and participation. The sidebar above shows a typical organizational structure that should be considered to help manage such an alliance.

Plan adequate training. Rules related to training activities refer to the alliance's overall mission and any drivers that will need to be established in both the owner's and the contractor's organizations.

Identify resource requirements related to business objectives. Attention will need to be devoted to the balance between continuity of work and deployment of key contractor's resources, as the deal has to avoid idle time, as much as possible. The key contractor professionals cannot remain idle waiting for work to come, as this would

impact their morale and motivation.

Capture and share lessons learned. A transparent feedback mechanism must be established to allow continuous improvement to occur throughout the life of the alliance.

Define terms related to R&D joint collaboration. Special provisions must be put in place to define how the contractor's personnel should collaborate with the owner to move the project forward from the R&D stage.

Commit to continuous improvement. The project owner and contractor should evaluate the deal in such a way as to avoid the *status quo,* and instead seek ongoing advancements and best practices.

Project-execution details

Set "engineering-reuse" goals. Within the context of continuous improvement, the reuse of engineering (in terms of leveraging the existing experience with continuous improvement and development of best practices in mind) must be a means to an end, and not the goal — hence underscoring the need for a smart, open-minded approach.

Establish productivity targets. Such targets are linked to the above-mentioned KPIs, and will provide an ongoing measure of the performance of the alliance with regard to key agreed-upon objectives.

Strive to optimize efforts related to specifications and standards. One of the advantages of an alliance should be to simplify and coordinate efforts related to helping the project meet the required specifications and standards. Working closely together, the partners can bring about a lean approach with less redundancy of effort.

Develop a project-execution strategy to ensure continuity of projects. A clear strategy will need to be developed to ensure smooth project execution, especially in terms of balancing the optimization of a single initiative versus a suite of projects (as these two competing drivers may not necessarily be aligned).

Set goals for cycle-time improvement. The partners in any alliance should seek to reduce project lifecycle time through standardization and efforts to improve efficiency.

Define change-management strategies (related to technology and project execution). Clear rules should be established, especially when management of change could affect alliance KPIs.

Establish a standardization philosophy. Likewise standardization should be exercised in a smart way, to balance progressive introduction of technology and project execution improvements with reuse of engineering.

Standardize engineering deliverables and documentation efforts. Efforts related to these key project objectives should be standardized wherever possible, aiming at simplifying the quality and quantity of deliverables based upon the owner's actual needs.

Coordination responsibilities

Manage information and seek consistency of messaging. Efforts should be made to streamline communications within and outside the alliance environment, and to properly monitor communications to ensure consistency of messaging.

Leverage alliance benefits to current projects and vice versa. There must be a useful transfer of value provisions from the alliance efforts to benefit all mutual projects, and a flow of wisdom and knowledge to make best use of project learnings and best practices to benefit all alliance partners. With a robust alliance framework and deliberate effort, specific learnings and best practices can then be carried forward from project to project.

Ensure understanding and implementation of alliance strategy by project teams. Proper training of the project teams can help to ensure that all participants are aligned and can exploit the many benefits of a well-designed alliance.

Interface with third parties. The partners should work to develop consistent rules at the outset, to specify homogeneous ways in which all parties should interface with the world beyond the alliance — for example, with regard to licensees, joint-venture partners, other contractors, manufacturers, suppliers and more.

Closing thoughts

Setting up a well-designed owner-contractor alliance takes effort, and maintaining it requires time and attention. The above-mentioned alignment areas should overcome any conflict among the parties, stimulating the proper top-down and bottom-up behaviors and processes that are, in an alliance, deeply different from a transactional deal. Alliances are not just deals; rather, when designed and executed appropriately, they can provide more in terms of "soft values."

The focus should be to create win-win solutions that are both possible and necessary for all parties. When the proper steps are taken to develop a strong alliance, all parties can exploit accelerated technology development, and benefit from leading project-management practices and tools, as well as proper effort to avoid the cost penalties associated with poor quality (with regard to project design and execution). Alliance members must seek ongoing productivity improvements, have the courage to speak up if any issues arise, and aim for consistent account management and accountability by all parties in the deal. ■

Edited by Suzanne Shelley

When certain questions can be answered — such as why does an owner seek an alliance, and what are its potential pitfalls (real or perceived)? — all stakeholders are able to develop an appropriate alliance agreement that is tailored to meet the site-specific considerations of the project or business endeavor

Author

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Selection of Silos for Bulk Storage

To determine what kind of storage silo is best for your site and your materials, begin by answering the following five questions

Tom Nomady
Imperial Industries

Selecting a silo for your bulk-solids storage needs isn't like picking out a pair of socks. It's a big decision. There are a lot of variables and plenty at stake, not the least of which is the safety of your colleagues and the success of your business. The high stakes can make the decision overwhelming. My experiences have taught me that there is a solution for every storage situation.

I have fielded every kind of question imaginable, from requests to simply increase storage capacity to those regarding the design of silos for storing unique materials — for instance, coal dust, plastic additives and others. Be confident that a solution exists. My recommendation is to begin the selection process by asking yourself the five questions discussed in this article before moving forward. All five represent critical variables that need to be addressed before a silo can be bid, designed, built or shipped. By first establishing the answers to these questions, you can turn what can be a confusing process into a rewarding one.

What material will be stored?

Create a list of specific requirements for your storage application before you engage a silo vendor. Tell the vendor the characteristics of the material being stored, including density, abrasiveness and particle size (for example, is it a fine powder or granular material?). Consider how the material will be fed into and discharged from the silo. This will help determine the most cost-effective option. Additionally, determine whether the material's composition is such that a silo will require flow-aid devices, such as bin activators, vibrators, aeration systems or mechanical agitation. Knowing the amount of the material needed to meet the supply-chain needs of your facility is also important.

FIGURE 1. Shown here are custom-made silos used to store materials in a high-technology plastics-manufacuturing facility

No matter what chemicals or materials you are storing, most silos will likely require other components, such as dust collector flanges, manways, nozzles, flow control, stairways and peripheral conveyor supports. It is helpful to familiarize yourself with these terms in advance, if you are not already. For specific information on structural steel construction, reference books, such as the Structural Engineering Handbook and the Manual Of Steel Construction [*1, 2*], can be useful.

Understand that most silos are pneumatically fed, some are gravity fed, and others have mechanical feeding systems. The feed and discharge systems are separate entities from the silo weldment and vary from user to user, depending on what material they are storing, what equipment they are familiar with, and how they want (or need) to handle the product. The feed and discharge parts of the system are the responsibility of the company that supplies the material handling equipment.

What is the construction timeline?

The construction of the silo can and should be a straightforward process. The objective is to avoid last-minute changes prior to construction. Changes can happen for a number of reasons, and can be quite costly. Common changes include a sudden requirement to add capacity, which could involve a height change, diameter change or even additional silos. Also, an change of the handling system design can affect the silo design. This can include changes to silo connections, discharge clearances and overall dimensions. Changes in product bulk density can also have a significant impact. For example, if a silo designed for a product density of 40 pounds per cubic foot (PCF) changes to one holding a material at 45 PCF, that would add a dead load of 25,000 lb for a 5,000-ft^3 silo.

Give careful thought to your construction timeline, budget and expectations at the planning stage. Don't rush anything. Build in plenty of time to adjust for conditions. Construction timelines will be influenced by the type of site you are building

on: a greenfield site is new construction; a brownfield site is adding to an existing facility. When installing a silo next to existing equipment on a brownfield site, downtime can be very costly. Make sure you talk to your site contractor about all the variables, including the use of a crane, the need to set up scaffolding and more. Spending time for upfront planning can go a long way toward ensuring the construction runs smoothly and on time.

To provide a sense of the duration of project stages, it is typical to allow three or four weeks for an engineering timeline, during which you would consider and approve drawings, and eight to ten weeks for fabrication of the silo, following the final project approval from the end user. Of course, lead times increase and decrease according to the size and complexity of the project.

How will your silo look?

The external appearance of the silo needs to be acceptable for both aesthetic and pragmatic reasons. Paint systems for silos can range from no coating at all to sophisticated multi-coat paint systems. The paint coatings not only determine the appearance of the silo to the public, but also serve as protection against corrosion and other damage. In most cases, coatings are essential for storage performance that meets the requirements of the application, such as corrosion and abrasion resistance. Higher-quality coatings mean more protection during the life of the silo.

The most common silo coatings tend to be epoxy primer with polyurethane topcoats. Custom coatings, which are usually user-specified, can range from primer only to high-end zinc prime/epoxy mid-coat/polyurethane topcoat. Custom color match is usually available and coating life usually can extend up to 20 years with proper maintenance.

It is important to take into account the impact of weather on the silo coating. Rain can cause inadequate coatings to delaminate from the surface of the structure. Heat and cold cycles can cause the silo's metal to expand and contract, which could cause the coatings to separate. The sun's ultraviolet rays can accelerate coating deterioration and chalking. If all of these factors are considered, the right coating can make the difference between a high-performaning silo and one that will fail prematurely.

Some coatings require inspection in order to satisfy federal, state and city regulations. With such a wide variety of paint options, your vendor needs to be a specialist in the field who can guide you through the decision-making. The good news is a quality vendor will be experienced in planning for all these scenarios.

Where will the silo be located?

Consider the size of the area where the silo will be located. This will help determine the silo type and construction method. Once the location is determined, consider how the silo will be maneuvered into place. Make sure the silo vendor is capable of transporting and installing the silo in the given area. It is essential to ask detailed questions about the logistics of the transport, including those about specialized trailers, which allow for maneuverability and can be lowered or raised in the

air depending on site circumstances. Silos generally can be manufactured up to 16 ft in diameter and shipped in one piece up to 90 ft long with a 90,000-lb weight. Construction, size and weight are defined by the structural requirements more so than the size requirements.

In geographic terms, the location of your silo can be affected by local building codes and other safety regulations that apply to the project. This affects the design, construction and installation of your silo and needs to be considered upfront. Some locations may require a permit, too. Vendors follow the current International Building Code standard building codes for the specific job site location in question. There are no specific design codes for dry bulk silos, so a combination of American Petroleum Institute (API), American Society of Mechanical Engineers (ASME) and American Water Works Association (AWWA) standards are used at certain times to calculate allowable stresses and other design factors.

How will the silo be maintained?

The objective here is to consider what will be needed to maintain high performance at minimal cost throughout the life of the silo. For example, make sure your silo has easy access to internal components for routine maintenance. Periodic inspection by plant maintenance personnel is required to keep up with paint touch-up and other minor issues. As your silo ages, look to your manufacturer to provide inspection services to ensure its safe and lasting operation. Eventually, many years down the road, these inspections can help you assess whether to repair or replace your silo.

There are more factors that go into the silo selection, such as the user's budget for storage and expectations about having the new silo in place before needing additional storage or material handling equipment. Also, it may help to include future needs, but if you address the questions mentioned here, you will position your company for selecting a storage silo that is quality-built and pleasing to the eye, and that will serve the company effectively for many years. ■

Edited by Scott Jenkins

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Economic Indicators

2016 2017 2018

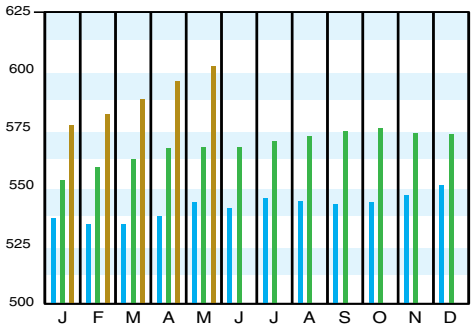
Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957–59 = 100)	May '18 Prelim.	Apr. '18 Final	May '17 Final
CE Index	601.8	595.0	567.3
Equipment	733.4	723.5	684.6
Heat exchangers & tanks	649.9	637.5	603.5
Process machinery	715.8	708.8	682.0
Pipe, valves & fittings	958.6	952.3	873.5
Process instruments	422.8	419.2	403.5
Pumps & compressors	1022.9	1015.6	979.6
Electrical equipment	534.0	533.2	516.4
Structural supports & misc.	797.3	776.0	737.1
Construction labor	332.1	331.6	326.1
Buildings	594.4	586.4	559.7
Engineering & supervision	308.8	310.4	313.6

Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)

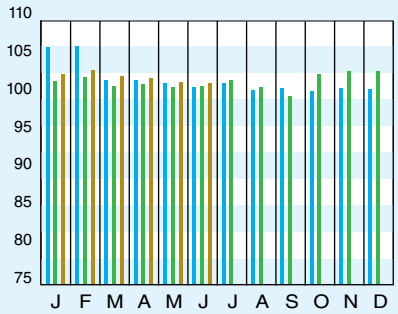
Annual Index:
2010 = 550.8
2011 = 585.7
2012 = 584.6
2013 = 567.3
2014 = 576.1
2015 = 556.8
2016 = 541.7
2017 = 567.5



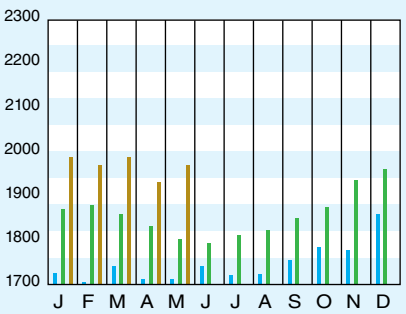
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS		YEAR AGO
CPI output index (2012 = 100)	Jun. '18 = 101.7	May '18 = 101.7	Apr. '18 = 102.0	Jun. '17 = 100.5
CPI value of output, $ billions	May '18 = 1,972.1	Apr. '18 = 1,940.4	Mar. '18 = 1,934.7	May. '17 = 1,742.0
CPI operating rate, %	Jun. '18 = 75.7	May '18 = 75.8	Apr. '18 = 76.1	Jun. '17 = 75.7
Producer prices, industrial chemicals (1982 = 100)	Jun. '18 = 273.9	May '18 = 267.7	Apr. '18 = 265.8	Jun. '17 = 251.5
Industrial Production in Manufacturing (2012 =100)*	Jun. '18 = 103.9	May '18 = 103.1	Apr. '18 = 104.2	Jun. '17 = 101.9
Hourly earnings index, chemical & allied products (1992 = 100)	Jun. '18 = 184.1	May '18 = 184.8	Apr. '18 = 187.3	Jun. '17 = 174.9
Productivity index, chemicals & allied products (1992 = 100)	Jun. '18 = 96.0	May '18 = 96.4	Apr. '18 = 95.8	Jun. '17 = 99.5

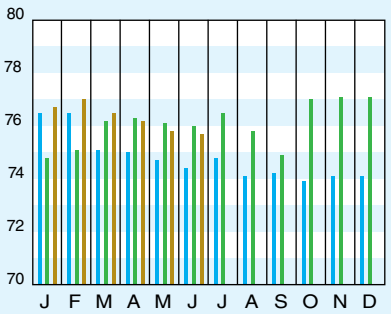
CPI OUTPUT INDEX (2000 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2000 to 2012
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the May 2018 *CE* Plant Cost Index (CEPCI; top; most recent available) once again increased substantially compared to the previous month's value, continuing a string of monthly increases since the beginning of 2018. The rise seems to be tied somewhat to increases in the components of the CEPCI that have to do with steel raw materials. The Equipment, Buildings and Construction Labor subindices all moved higher for May, while the Engineering & Supervision subindex was slightly lower. The overal CEPCI for May stands at 6.1% higher than the corresponding value from May of last year. Meanwhile, the Current Business Indicators (CBI; middle) saw the CPI output index stay stable for June 2018.